APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED

AFPTEF REPORT NO. 06-R-03
AFPTEF PROJECT NO. 04-P-103

MATTHEW P. BOZZUTO
Project Engineer
matthew.bozzuto@wpafb.af.mil
DSN 787-7166
Comm (937) 257-7166

SUSAN J. EVANS
Qualification Test Engineer
susan.evans@wpafb.af.mil
DSN 787-7445
Comm (937) 257-7445

Development of the C-17 – Main Landing Gear Post Container, CNU-677/E

AFMC LSO/LOP
AIR FORCE PACKAGING TECHNOLOGY & ENGINEERING FACILITY
WRIGHT PATTERSON AFB, OH 45433-5540
April 2007

NOTICE

AFPTEF PROJECT NO. 04-P-103
TITLE: Development of the C-17 – Main Landing Gear (MLG) Post Container

ABSTRACT

The Air Force Packaging Technology Engineering Facility (AFPTEF) was tasked with the design of a new shipping and storage container for the C-17 MLG Post in March of 2004. The new container is designed to replace the wood container that was previously used.

The main problem with the wood design was corrosion due to inadequate environmental control and protection. In addition, there were two different container configurations to accommodate a left or right post. AFPTEF applied proven container design methods to solve the corrosion problem as well as simplified the container configuration to accept either right or left posts, eliminating the need for different containers.

The CNU-677/E, designed to SAE ARP1967A, is an aluminum, long-life, controlled breathing, reusable shipping and storage container. The new container, CNU-677/E, protects the Post mechanically and environmentally. The container passed all qualification tests per ASTM D4169.

The CNU-677/E container not only meets user requirements but also provides an economic saving for the Air Force. The savings will be thousands of dollars per MLG post over the twenty-year life span of the container.

Total man-hours: 500

PROJECT ENGINEER:

Matthew P. Bozzuto
Mechanical Engineer
AFPTEF

TEST ENGINEER:

Susan J. Evans
Mechanical Engineer
AFPTEF

APPROVED BY:

Robbin L. Miller
Chief, Air Force Packaging
Technology & Engineering
Facility

PUBLICATION DATE:

Apr 2 2007

TABLE OF CONTENTS

INTRODUCTION

BACKGROUND – The C-17 main landing gear (MLG) post is currently stored in a wood container. The container does not have environmental controls and is not sealed by the nature of its construction. These two factors allow the container to "breathe" with continuously changing environmental conditions. There is no means to control breathing or remove the excess moisture that results, which causes a corrosion problem on the post. There was no damage reported as a result of inadequate shock protection, indicating that the cradle system is adequate. The C-17 post container is one of a family of new AFPTEF container designs to protect items that are being damaged in the shipping and storage cycle. Containers were also designed for the MLG axle beams, full MLG assemblies, nose landing gear assembly, nose radome, HUD, brake assembly, and thrust reversers. Logistics and Sustainment personnel at Robins AFB contacted AFPTEF to request the design of a reusable container that would eliminate the shipping and storage risks.

REQUIREMENTS – AFPTEF and Robins AFB personnel agreed upon a list of requirements during initial design discussions. Many of these requirements were not met by the wood container. The requirements are as follows:

- Sealed/controlled-breathing container that protects against varied environmental conditions and weather during either inside or outside shipping and storage
- No loose packing material
- Post Shock/Vibration limited to 50 Gs
- Reusable and designed for long life (20 years)
- Usable with any post version (left aft, left fdw, right aft, right fwd)
- Low maintenance
- Field repairable hardware
- Forklift capabilities

DEVELOPMENT

DESIGN – The C-17 MLG post Shipping and Storage Container (CNU-677/E) design meets all the users' requirements. The CNU-677/E is a sealed, welded aluminum, controlled breathing, reusable container. The container is engineered for the physical and environmental protection of the post during worldwide transportation and storage. The container consists of a base and completely removable cover equipped with the special features listed below. The base is a one piece skid/double walled base extrusion with forklift openings, humidity indicator, pressure equalizing valve (1.0 psi pressure/ 1.0 psi vacuum) and desiccant port for easy replacement of desiccant (controls dehumidification). A silicone rubber gasket and quick release cam-over-center latches create a water/air-tight seal at the base-cover interface. Container external dimensions are 77.8 inches length, 62.1 inches width, and 36.9 inches height. Container empty weight is 578 pounds, and 1323 pounds with the post in place.

An aluminum cradle system is integrated into the base design that rigidly mounts the post to the container base (See Appendix 2, Figures 1-2). The post is attached to the cradle system with three large silicone-lined aluminum clamps with quick release handles that make loading and unloading easy and safe. There are no detachable parts on the container other than the container lid, which eliminates FOD risks.

TFR ANTENNA CONTAINER FEATURES	
Pressure Equalizing Valve	1
Humidity Indicator	1
Desiccant Port	1
Document Receptacle	None
Forkliftable	Yes
Cover Latches	18
Cover Lift Handles	4
Cover Lift Rings	2
Cover Tether Rings	None
Base Lift Handles	None
Base Tie-down Rings	4
Stacking Capability	Yes

PROTOTYPE – AFPTEF fabricated one CNU-677/E prototype container in house for testing. The prototype container was fabricated in accordance with (IAW) all requirements and tolerances of the container drawing package, and had a tare weight of 578 lb. The drawing package used for prototype fabrication has been released for the manufacture of production quantities of the container. Each face of the container was uniquely identified for testing identification as shown below.

DESIGNATED SIDE	CONTAINER FEATURE
Top	Cover Top
Aft	Desiccant Port
Right	Right Side from Aft
Left	Left Side from Aft
Forward	Opposite Aft
Bottom	Base Bottom

QUALIFICATION TESTING

TEST LOAD – The test load was an unserviceable MLG Post, with steel blocks welded onto each of the 3 post ends to simulate bearing housings and post design changes.

TEST PLAN – The MLG Post container was tested in accordance with the Air Force Packaging Technology & Engineering Facility (AFPTEF) standard long life container test plan (See Appendix 1).

The test plan referenced ASTM D 4169 and SAE ARP 1967. The test methods specified in this test plan constituted the procedure for performing the tests on the post container. The performance criteria for evaluation of container acceptability was specified at 50 Gs maximum and an initial and final leak rate of 0.35 kPa (0.05 psi/hr) at 6.9 kPa (1.0 psi). These tests are commonly applied to special shipping containers providing rough handling protection to sensitive items. The tests were performed at AFPTEF, AFMC LSO/LOP, 5215 Thurlow St, Wright-Patterson AFB, OH 45433-5540.

ITEM INSTRUMENTATION – The test load was instrumented with a piezoelectric triaxial accelerometer mounted as close as possible to the MLG post's center of mass. Accelerometer positive axis orientations were as follows:

X Axis - Directed through container Forward and Aft sides (Longitudinal motion).
Y Axis - Directed through container Left and Right sides (Transverse motion).
Z Axis - Directed through container Top and Bottom (Vertical motion).

See Appendix 4 for detailed accelerometer and other instrumentation information.

TEST SEQUENCES – Note: All test sequences were performed at ambient temperature and humidity, unless otherwise noted in the test procedure.

TEST SEQUENCE 1 – Leak Test

Procedure – The desiccant port cover was removed and replaced with a port cover modified for attachment of the digital manometer and vacuum/pressure pump lines. The container was closed and sealed. The pneumatic pressure leak technique was used to pressurize the container to minimum test pressure of 6.9 kPa (1.0 psi). (See Appendix 2, Figure 3)

Results – The container passed the leak test with a leak rate less than the maximum allowed rate of 0.35 kPa (0.05 psi).

TEST SEQUENCE 2 – Vibration Test, Resonance Dwell

Procedure – The container was rigidly attached to the vibration platform (Appendix 2, Figure 4). A sinusoidal vibration excitation was applied in the vertical direction and cyclically swept for 7.5 minutes at 2 minutes per octave to locate the resonant frequency. Input vibration from 5 to 12.5 Hz was at 0.125-inch double amplitude. Input vibration from 12.5 to 50.0 Hz was at 1.0 G (0 to peak). The peak transmissibility values during the up and down frequency sweeps were noted for use in determining the frequency search range for the resonance dwell test.

Acceleration pulses were recorded to determine the maximum accelerations sustained by the packaged item. All signals were electronically filtered using a two-pole Butterworth filter with a 600 Hz cutoff frequency.

The vibration controller swept up the frequency range until the resonant frequency was reached. The controller locked onto and tracked this frequency for the 30 minute resonance dwell test. The resonant frequency and corresponding transmissibility at 1 minute, 15 minutes and 30 minutes into the test were recorded. The test was conducted at ambient temperature.

Results – The initial resonant frequency of the container was 19.4 Hz. The controller was manually locked onto this frequency, and a manually controlled check for a change in the resonant frequency was performed every 10 minutes for the duration of the 30 minute resonance dwell test. During this period, the average transmissibility of the container and cradle/shock mount system was 1.7. This is lower than the maximum allowable transmissibility, 8, when the resonant frequency is between 15 and 25 Hz (See Appendix 3, Table 2 and frequency/transmissibility tables at the end of Appendix 3). The container met the test requirements.

TEST SEQUENCE 3 – Loose Load Vibration, Repetitive Shock

Procedure – A sheet of 3/4-inch plywood was bolted to the top of the vibration table, and the container was placed on the plywood. Restraints were used to prevent the container from sliding off the table. The container was allowed approximately 1/2-inch unrestricted movement in the horizontal direction from the centered position on the table (Appendix 2, Figure 5).

The table frequency was increased from 3.5 Hertz (Hz) until the container left the table surface (approximately 4.3 Hz). At one-inch double amplitude, a 1/16-inch-thick flat metal feeler could be slid freely between the table top and the container under all points of the container. Repetitive shock testing was conducted for 2 hours at ambient temperature.

Results – The loaded container was vibrated at 4.3 Hz for 2 hours. The maximum G level (vertical axis) measured during this time was 2.3. At the end of testing

there was no visible damage to the either the container or the item. The container met the test requirements.

TEST SEQUENCE 4 – Rotational Drops

Procedure – An Assurance Level I drop height of 305 mm (12 in.) was used to perform four corner and four edge drops were onto a one-inch thick steel plate. (See Appendix 2, Figures 6 & 7.)

Results – There was no noticeable damage to either the container or item. Although the test item shifted 1.5 mm forward during one impact (forward-right corner) it did not make contact with any interior container surfaces during testing, and no further shifting occurred during any other impacts. The some of the silicone rubber strips lining the hinged clamps did tear loose from the adhesive used; the design engineer will use a stronger adhesive to prevent this from happening in the production containers. The maximum recorded (resultant) impacts ranged from 12 Gs to 27 Gs, well below the item fragility of 50 Gs (See Appendix 3, Table 1). The container met the test requirements.

TEST SEQUENCE 5 – Lateral Impact (Pendulum Impact)

Procedure – Upon completion of test sequence 4, the container was on the test apparatus and impacted. The container impact velocity was 2.13 m/sec. Each of the four container sides was impacted once time. (See Appendix 2, Figure 8.)

Results – No noticeable damage occurred to the container or item. The item did not make contact with any interior container surfaces during testing. The maximum recorded (resultant) impacts ranged from 14 Gs to 27 Gs (See Appendix 3, Table 1), well below the item fragility of 50 Gs. The container met the test requirements.

TEST SEQUENCE 6 – Leak Test

Procedure – Test Sequence 1 was repeated.

Results – The container passed the leak test with a leak rate less than the maximum allowed rate of 0.35 kPa (0.05 psi).

TEST CONCLUSIONS – No damage occurred during the above testing to either the container, mounting system or test item. There was no evidence of any contact on impact between the MLG Post and the container walls or lid. All impact levels are well below the item fragility limit of 50 Gs. Therefore, the container and mounting system do provide adequate protection for the MLG Post.

FIT & FUNCTION TESTING

Fit and function testing was completed on site at AFPTEF with the MLG post that was supplied for prototype testing. In addition, the packaging process was also verified for all

four post configurations at the Boeing Support Systems Center (BSSC) near San Antonio, TX during the testing phase of the project.

CONCLUSIONS

No damage occurred during the above testing to the container, mounting system or test item. There was no evidence of any contact on impact between the MLG Post and the container walls or lid. All impact levels are well below the item fragility limit of 50 Gs. The CNU-677/E aluminum container was accepted by the users at BSSC. The container met all the user's requirements. The container can protect a MLG post during world-wide transportation and storage and will save the Air Force hundreds of thousands of dollars in O&M costs.

RECOMMENDATIONS

AFPTEF recommends that new containers be procured and delivered to avoid damage to main landing gear posts, thus mitigating overall shipping risks. All wood crates for the main landing gear posts should be replaced.

APPENDIX 1: Test Plan

AIR FORCE PACKAGING EVALUATION ACTIVITY
(Container Test Plan)

AFPEA PROJECT NUMBER: 04-P-103

CONTAINER SIZE (L x W x D) (MILLIMETERS) INTERIOR:	EXTERIOR:	WEIGHT (Kgs) GROSS:	ITEM:	CUBE (CU. M)	QUANTITY:	DATE:
1887 X 1488 X 796	1977 X 1578 X 936	600	338	2.9	1	14 Jul 04

ITEM NAME: C-17 POST ASSEMBLY, MAIN LANDING GEAR
MANUFACTURER: AFPTEF

CONTAINER NAME: MLG POST CONTAINER
CONTAINER COST:

PACK DESCRIPTION: Aluminum Container

CONDITIONING: As noted below

TEST NO.	REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S	TEST TITLE AND PARAMETERS	CONTAINER ORIENTATION	INSTRU-MENTATION
1.	**Examination of Product.**			
	ARP1967 Par. 4.5.1 Table I	Container shall be carefully examined to determine conformance with material, workmanship, and requirements as specified in Table and drawings.	Ambient temp.	Visual Inspection (VI)
2.	**Quality Conformance Tests.**			
	Weight Test.			
	ARP1967 Par. 4.5.8.3.7	Container shall be weighed.	Ambient temp.	Scale
	Performance Tests.			
3.	**Leak Test.***	Pneumatic pressure at 6.9 kPA and vacuum retention at -6.9 kPA. After temperature stabilization, pressure drop shall not exceed 0.35kPA per hour. Test shall last a minimum of 30 minutes.	Ambient temp.	Water Manometer (WM) or Pressure Transducer (PPT)
	ARP1967 Par. 4.5.2			
4.	**Vibration Test.**			
a.	**ARP1967 Par. 4.5.5 ASTM D4169 ASTMD999**	The container shall be vibrated from 5 Hz to 50 Hz at a sweep rate of one half octave per minute with a total sweep time of 7.5 minutes. Container shall then be vibrated for 30 minutes at the predominant resonance. Input excitation shall be 3.2mm double amplitude or 1 G whichever is less.	Ambient temp. Rigidly attach container to exciter.	VI Tri-axial accelerometer

COMMENTS:
* Leak Test (pressure only) to be performed after each Vibration and Rough handling test.

PREPARED BY: Matthew Bozzuto, Mechanical Engineer
APPROVED BY:

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)					**AFPEA PROJECT NUMBER:** 04-P-103	
CONTAINER SIZE (L x W x D) (MILLIMETERS) INTERIOR:	**EXTERIOR:**	**WEIGHT (Kgs) GROSS:**	**ITEM:**	**CUBE (CU. M)**	**QUANTITY:**	**DATE:**
1887 X 1488 X 796	1977 X 1578 X 936	600	338	2.9	1	14 Jul 04
ITEM NAME: C-17 POST ASSEMBLY, MAIN LANDING GEAR				**MANUFACTURER:** AFPTEF		
CONTAINER NAME: MLG POST CONTAINER					**CONTAINER COST:**	
PACK DESCRIPTION: Aluminum Container						
CONDITIONING: As noted below						

TEST NO.	**REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S**	**TEST TITLE AND PARAMETERS**	**CONTAINER ORIENTATION**	**INSTRU-MENTATION**
b.	**ARP 1967 Par. 4.5.5 ASTM D4169 ASTM D999**	Container shall be vibrated IAW ASTM D4169, Method D999 for not less than two hours.	Ambient temp. Blocking shall be used to keep cntr. In place, do not restrict vertical or rotational move-ment.	VI Tri-axial accelerometer
5.	**Rough Handling Tests (Ambient Temperature)**			
a.	**ARP1967 Par. 4.5.3.2 ASTM D4169 ASTM D6179**	Corner-wise drop (rotational) test. Drop height: 305mm. Item shall not sustain more than 50G's.	One drop on each corner—total of four drops.	VI Tri-axial accelerometer
b.	**ARP1967 Par. 4.5.3.1 ASTM D4169 ASTM D6179**	Edge-wise drop (rotational) test. Drop height: 305mm. Item shall not sustain more than 50G's.	One drop on each edge—total of four drops.	VI Tri-axial accelerometer
c.	**ARP1967 Par. 4.5.6 ASTM D4169 ASTM D880**	Lateral-Impact test. Impact velocity 2.13 m/sec. Item shall not sustain more than 50G's.	One impact on each side and on each end—total of four impacts.	VI Tri-axial accelerometer

COMMENTS:

PREPARED BY: Matthew Bozzuto, Mechanical Engineer	**APPROVED BY:**

AIR FORCE PACKAGING EVALUATION ACTIVITY (Container Test Plan)					**AFPEA PROJECT NUMBER:** 04-P-103	
CONTAINER SIZE (L x W x D) (MILLIMETERS) INTERIOR:	**EXTERIOR:**	**WEIGHT (Kgs) GROSS:**	**ITEM:**	**CUBE (CU. M)**	**QUANTITY:**	**DATE:**
1887 X 1488 X 796	1977 X 1578 X 936	600	338	2.9	1	14 Jul 04
ITEM NAME: C-17 POST ASSEMBLY, MAIN LANDING GEAR				**MANUFACTURER:** AFPTEF		
CONTAINER NAME: MLG POST CONTAINER					**CONTAINER COST:**	
PACK DESCRIPTION: Aluminum Container						
CONDITIONING: As noted below						

TEST NO.	**REF STD/SPEC AND TEST METHOD OR PROCEDURE NO'S**	**TEST TITLE AND PARAMETERS**	**CONTAINER ORIENTATION**	**INSTRU-MENTATION**
6.	**Leak Test.** **ARP1967 Par. 4.5.2**	Pneumatic pressure at 6.9 kPA. After temperature stabilization, pressure drop shall not exceed 0.35 kPA per hour. Test shall last a minimum of 30 minutes	Ambient temp.	Water Manometer (WM) or Pressure Transducer (PPT)

COMMENTS:

PREPARED BY: Matthew Bozzuto, Mechanical Engineer	**APPROVED BY:**

PAGE 3 **OF** 3

APPENDIX 2: Fabrication & Testing Photographs

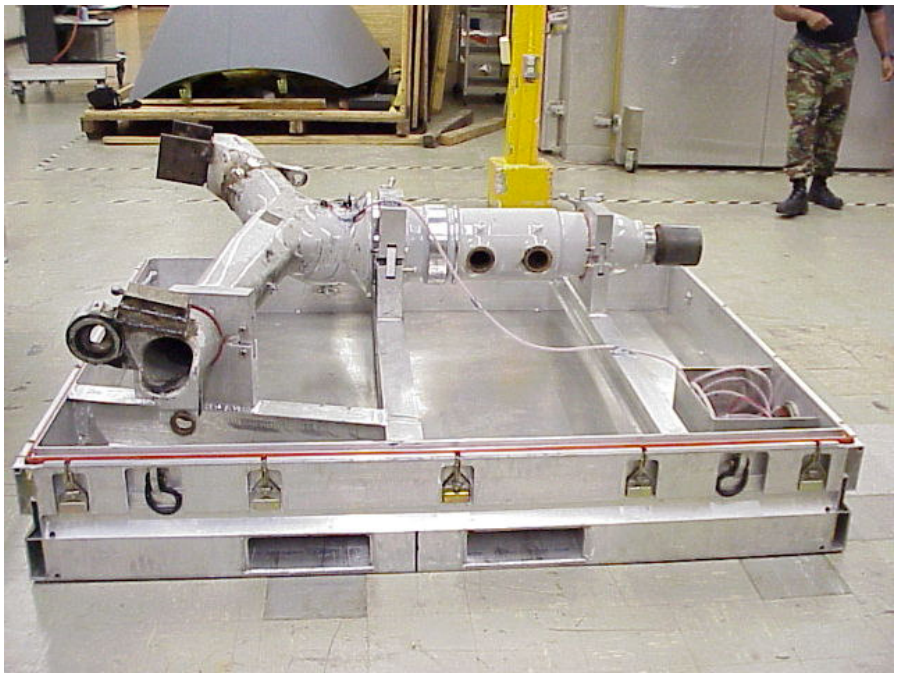


Figure 1. The post is mounted with three silicone lined clamps.

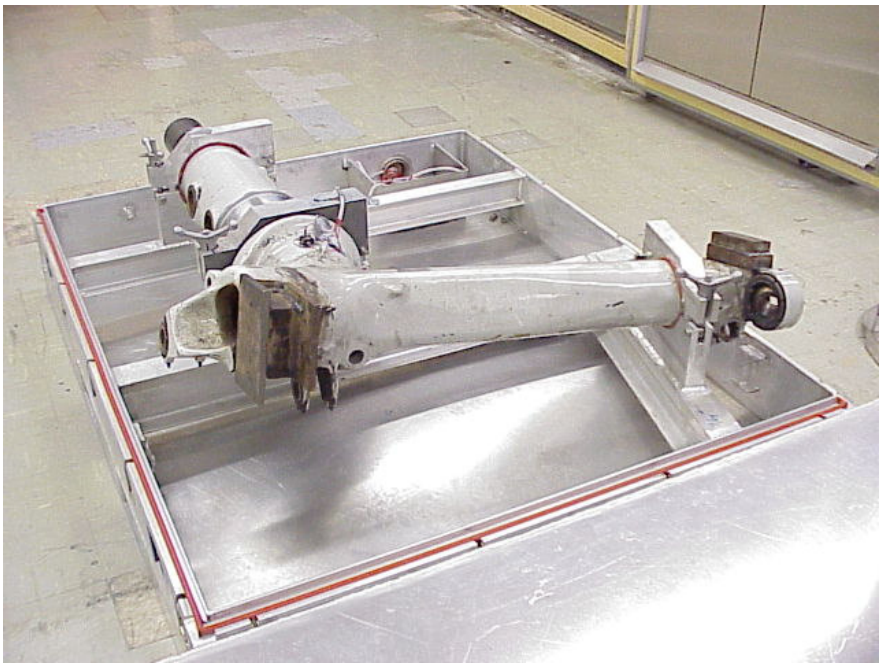


Figure 2. View looking toward the aft of the container.

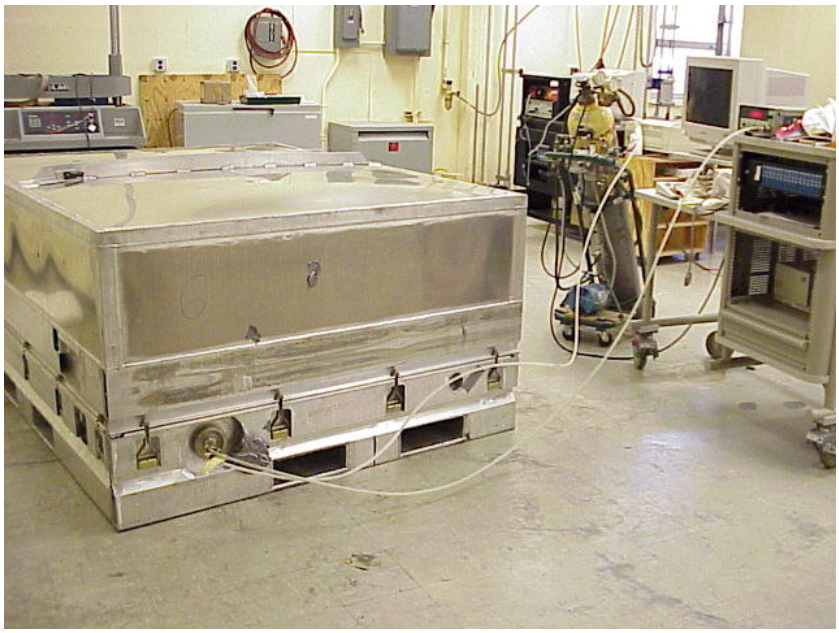


Figure 3. Pressure Test.

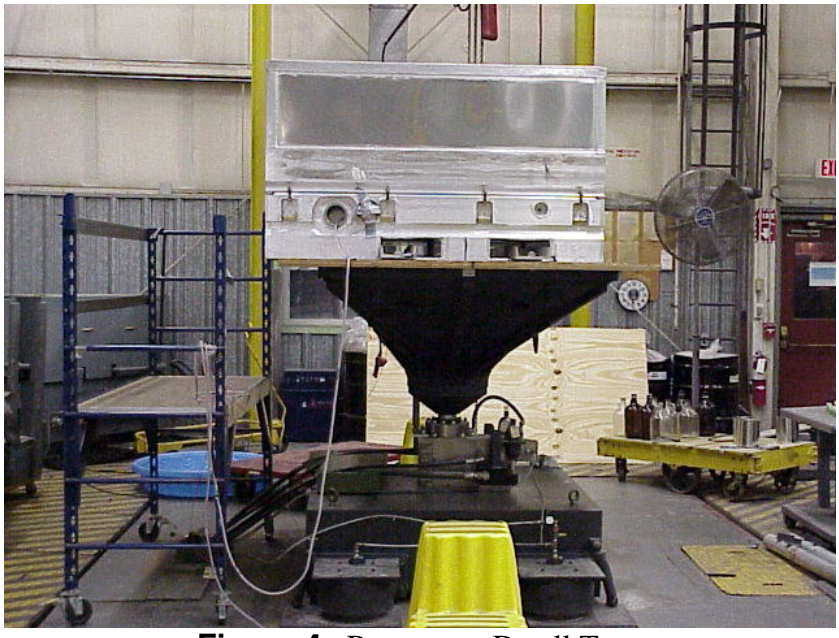


Figure 4. Resonance Dwell Test.

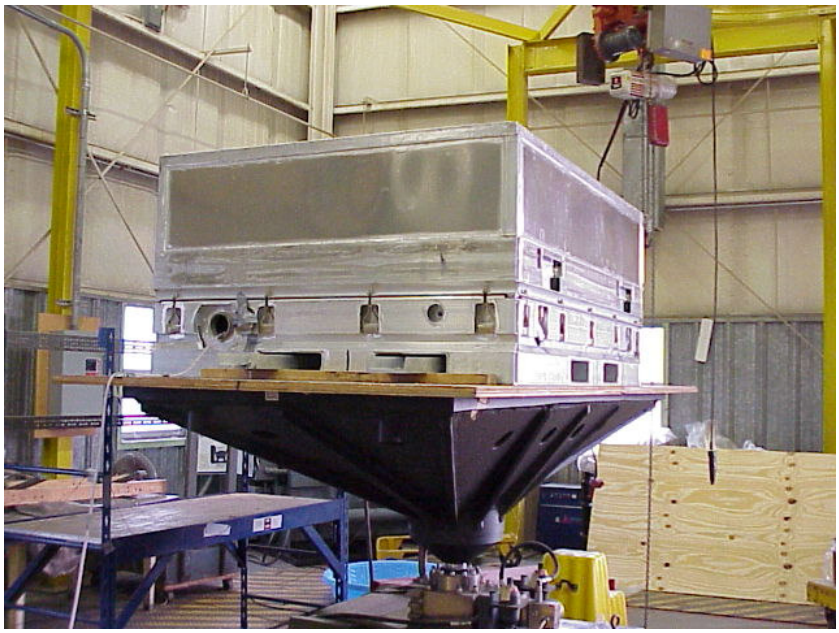


Figure 5. Repetitive Shock Test.

Figure 6. Rotational Edge Drop Test.

Figure 7. Rotational Corner Drop Test

Figure 8. Pendulum Impact Test.

APPENDIX 3: Test Data

Table 1. Impact Test Summary

IMPACT TYPE	TEST TEMPERATURE	IMPACT LOCATION	RESULTANT PEAK G
ROTATIONAL - CORNER	ambient	forward-left	16
ROTATIONAL - CORNER	ambient	forward-right	19
ROTATIONAL - CORNER	ambient	aft-left	13
ROTATIONAL - CORNER	ambient	aft-right	13
ROTATIONAL - EDGE	ambient	forward-bottom	24
ROTATIONAL - EDGE	ambient	aft-bottom	18
ROTATIONAL - EDGE	ambient	left-bottom	12
ROTATIONAL - EDGE	ambient	right-bottom	26
LATERAL IMPACT - FACE	ambient	forward	20
LATERAL IMPACT - FACE	ambient	aft	15
LATERAL IMPACT - FACE	ambient	left	26
LATERAL IMPACT - FACE	ambient	right	27

Table 2. Container Resonant Frequency and Transmissibility Values.

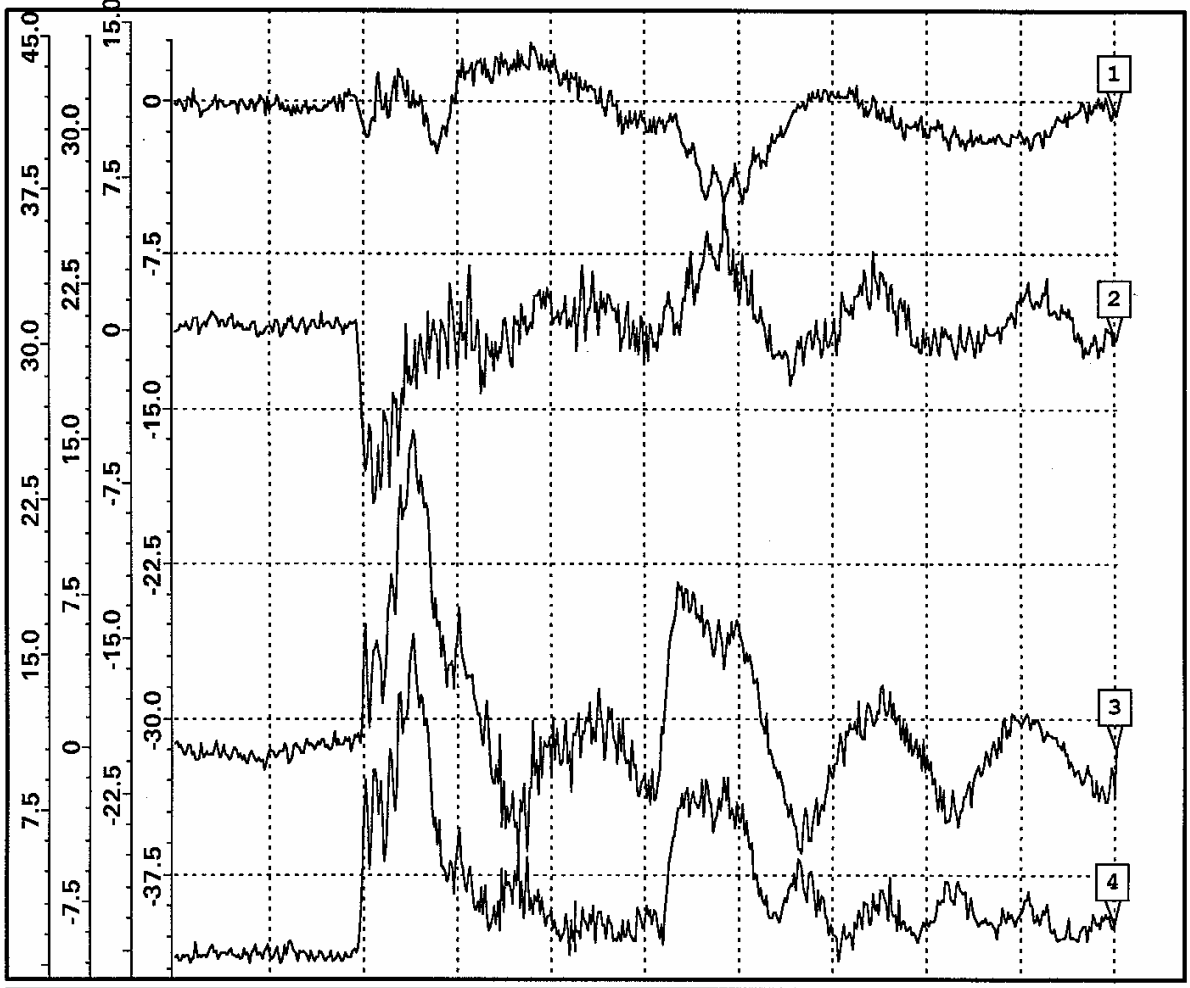
TEST TEMPERATURE	DWELL TIME	RESONANT FREQUENCY	TRANSMISSIBILITY
Ambient	1 min	19.45 Hz	1.8
Ambient	15 min	19.16 Hz	1.7
Ambient	30 min	17.78	1.6

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

	Aug 26 2004 14:39	TEST ENGINEER :	Evans
TEST TYPE :	Cornerwise Impact	IMPACT POINT :	forward-left
CONTAINER/ITEM:	C17 Post	DROP HEIGHT :	12 inches

V. Angle: 56.98;H.Angle: 20.66;



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div		Hexp	Vexp
○	1	111.	mS	1.07 g's	3.39 g's	12.20 In/s	26	mS	1	2
○	2	111.	mS	1.54 g's	-8.88 g's	-23.23 In/s	26	mS	1	2
○	3	111.	mS	0.58 g's	16.02 g's	73.19 In/s	26	mS	1	2
◉	R	111.	mS	1.95 g's	16.20 g's	77.75 In/s	26	mS	1	2

PEAK G RESULTANT VALUE = 16 Gs. PEAK G (Z) = 16 Gs.
Accelerometer output: Ch1 - X(long.); Ch2 - Y(trans.); Ch 3 - Z(vert.);
Ch4 - resultant. Aft side = desiccant port end.
No visible damage.
ASTM D 4169, ASTM D 6179, SAE ARP1967.

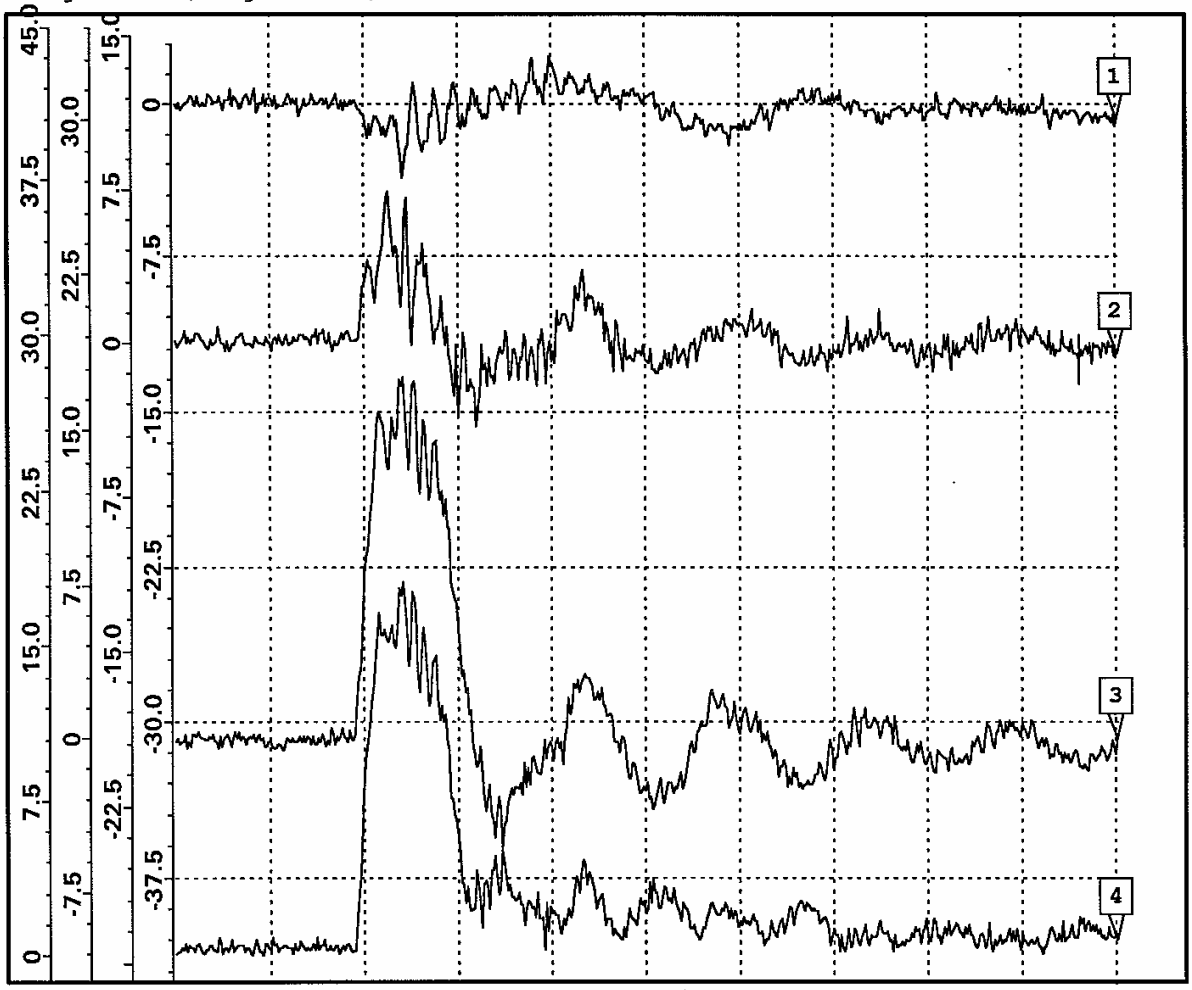
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

	Aug 26 2004 14:42	TEST ENGINEER :	Evans
TEST TYPE :	Cornerwise Impact	IMPACT POINT :	forward right
CONTAINER/ITEM:	C17 Post	DROP HEIGHT :	12 inches

V. Angle: 109.89;H.Angle: 242.10;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○	1	250. mS	-0.57 g's	-3.95 g's	-13.38 In/s	26 mS	1	2
◉	2	250. mS	-0.74 g's	7.67 g's	31.06 In/s	26 mS	1	2
○	3	250. mS	-1.40 g's	18.12 g's	100.55 In/s	26 mS	1	2
○	R	250. mS	1.87 g's	18.67 g's	106.08 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 19 Gs. PEAK G (Z) = 18 Gs.
Accelerometer output: Ch1 - X(long.); Ch2 - Y(trans.); Ch 3 - Z(vert.);
Ch4 - resultant. Aft side = desiccant port end.
No visible damage. Shifted 1.5 mm additional.
ASTM D 4169, ASTM D 6179, SAE ARP1967.

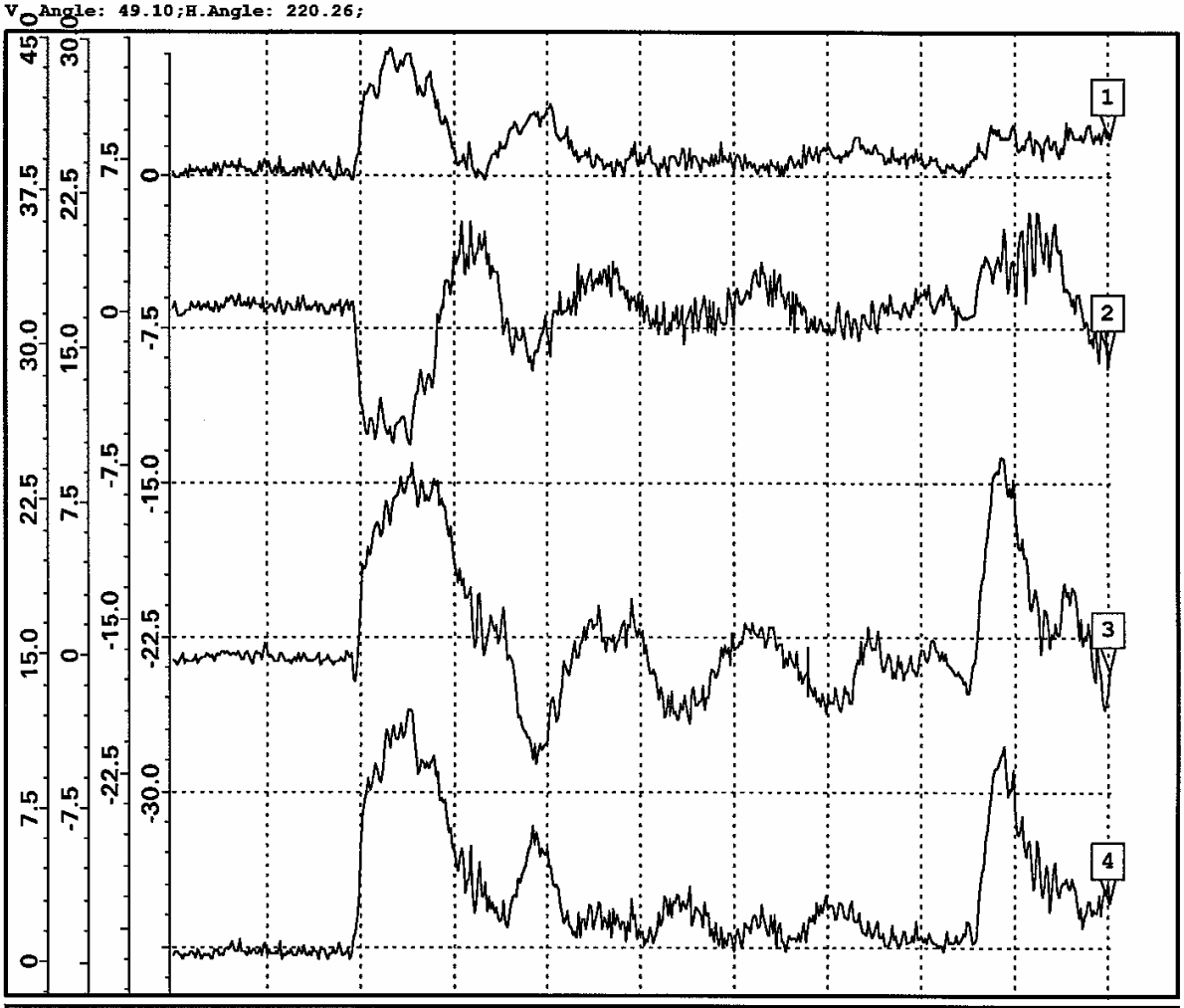
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

Aug 26 2004 14:07 TEST ENGINEER : Evans
TEST TYPE : Cornerwise Impact IMPACT POINT : aft-left corner
CONTAINER/ITEM: C17 Post DROP HEIGHT : 12 inches

V.Angle: 49.10;H.Angle: 220.26;



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div		Hexp	Vexp
○	1	177.	mS	1.12 g's	6.55 g's	87.30 In/s	26	mS	1	2
○	2	177.	mS	-0.99 g's	-6.93 g's	-15.26 In/s	26	mS	1	2
◉	3	177.	mS	-0.84 g's	9.54 g's	56.34 In/s	26	mS	1	2
○	R	177.	mS	1.71 g's	12.83 g's	105.02 In/s	26	mS	1	2

PEAK G RESULTANT VALUE = 12 Gs. PEAK G (Z) = 10 Gs.
Accelerometer output: Ch1 - X(long.); Ch2 - Y(trans.); Ch 3 - Z(vert.);
Ch4 - resultant. Aft side = desiccant port end.
No visible damage.
ASTM D 4169, ASTM D 6179, SAE ARP1967.

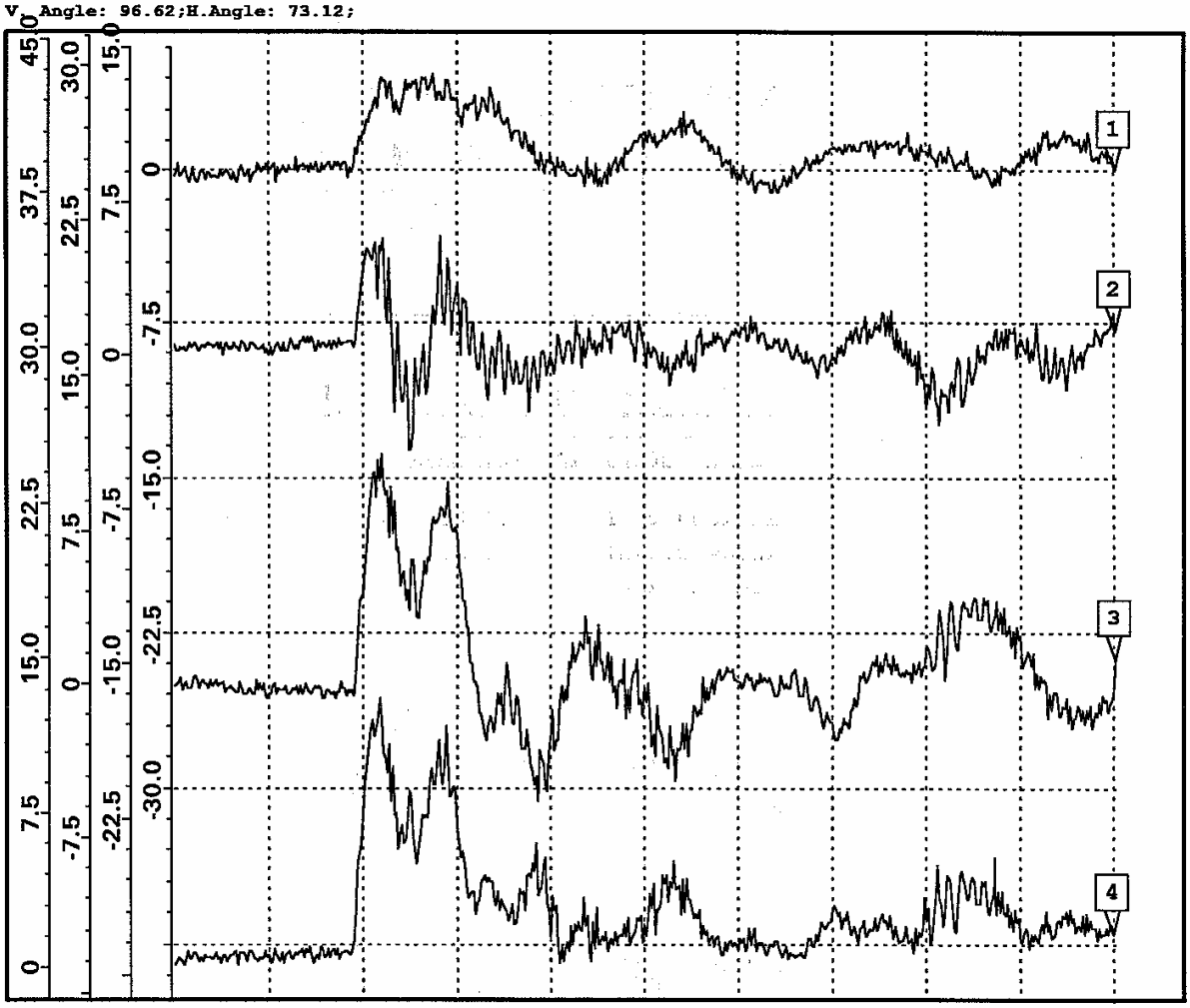
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

Aug 26 2004 14:31 TEST ENGINEER : Evans
TEST TYPE : Cornerwise Impact IMPACT POINT : aft-right corner
CONTAINER/ITEM: C17 Post DROP HEIGHT : 12 inches

V. Angle: 96.62;H.Angle: 73.12;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	227. mS	-0.39 g's	5.37 g's	89.05 In/s	26 mS	1	2
2	227. mS	0.99 g's	-6.59 g's	30.82 In/s	26 mS	1	2
3	227. mS	3.25 g's	11.34 g's	62.11 In/s	26 mS	1	2
R	227. mS	4.20 g's	13.28 g's	112.86 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 13 Gs; PEAK G (Z) = 11 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 999, SAE ARP 1967.

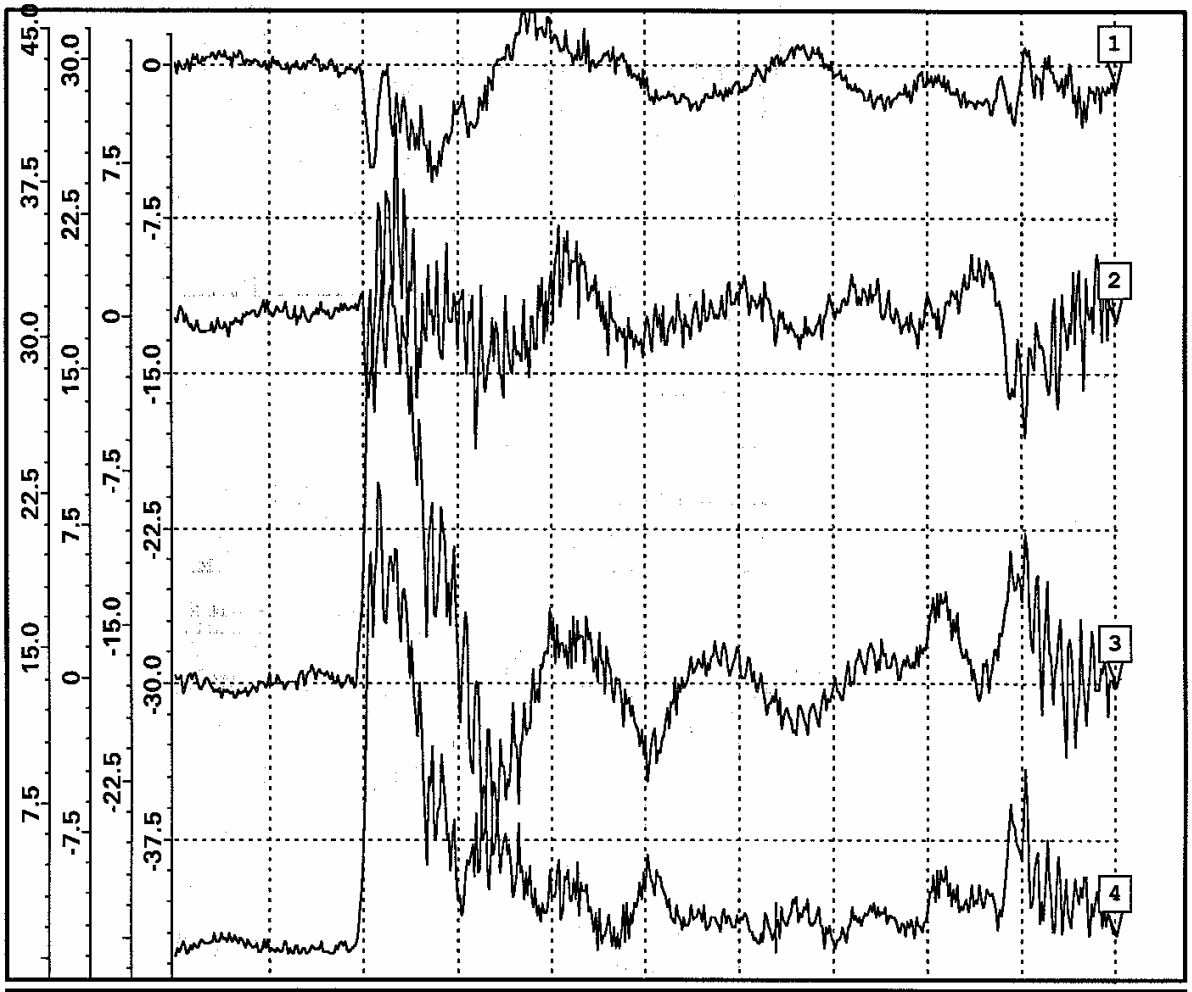
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

Aug 26 2004 14:35 TEST ENGINEER : Evans
TEST TYPE : Edgewise Impact IMPACT POINT : Foward-bottom edge
CONTAINER/ITEM: C17 Post DROP HEIGHT : 12 inches

V. Angle: 76.96;H.Angle: 202.38;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○	1	166. mS	0.33 g's	-6.45 g's	-44.56 In/s	26 mS	1	2
○	2	166. mS	-1.33 g's	9.87 g's	9.25 In/s	26 mS	1	2
○	3	166. mS	-0.55 g's	24.05 g's	85.92 In/s	26 mS	1	2
◉	R	166. mS	1.48 g's	24.13 g's	97.23 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 24 Gs; PEAK G (Z) = 24 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 6179, SAE ARP 1967.

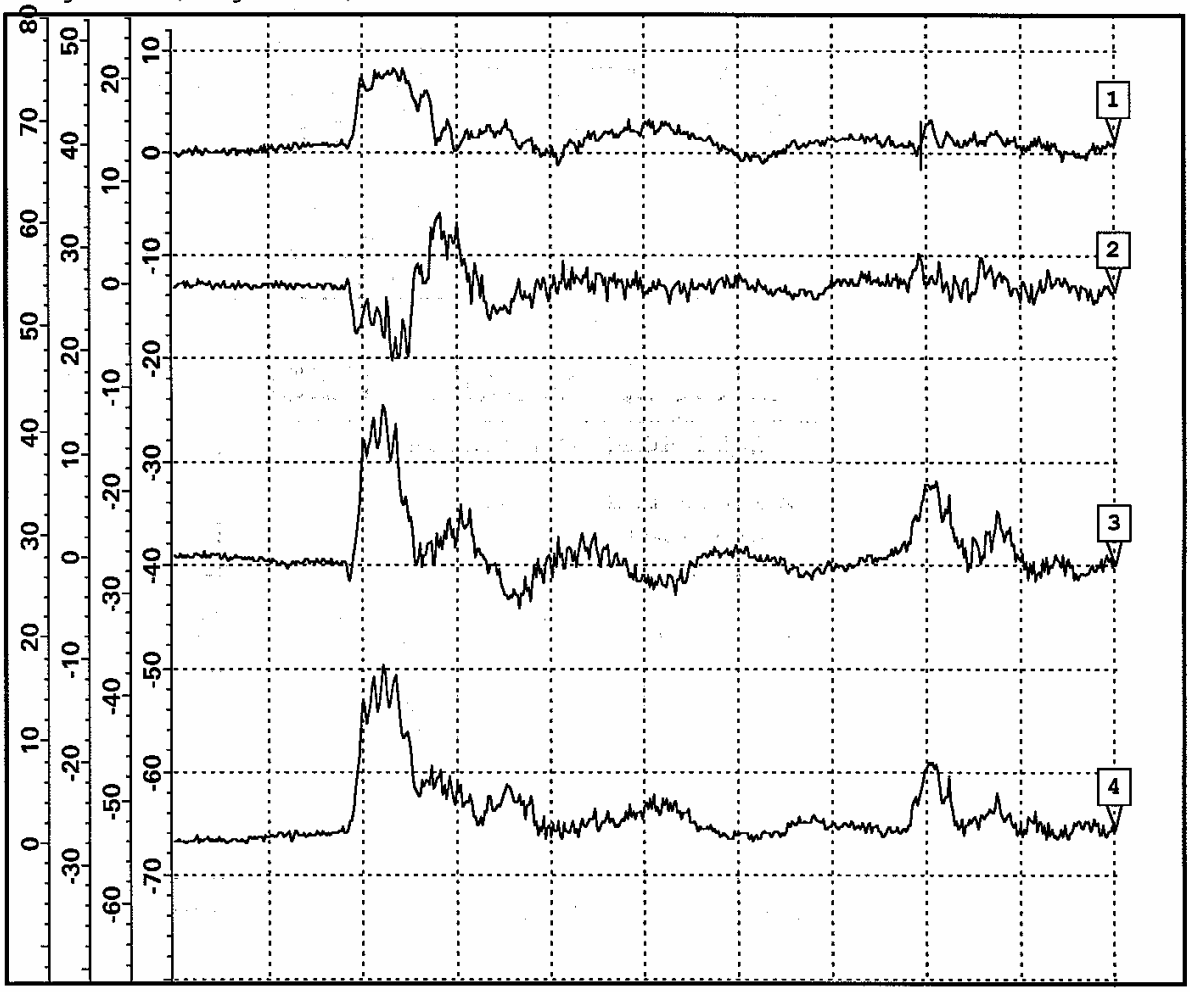
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

Aug 26 2004 14:04 TEST ENGINEER : Evans
TEST TYPE : Edgewise Impact IMPACT POINT : Aft-bottom edge
CONTAINER/ITEM: C17 Post DROP HEIGHT : 12 inches

V. Angle: 82.72;H.Angle: 66.59;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	207. mS	0.74 g's	8.96 g's	126.87 In/s	26 mS	1	2
2	207. mS	2.29 g's	-8.52 g's	-33.35 In/s	26 mS	1	2
3	207. mS	5.29 g's	15.18 g's	31.02 In/s	26 mS	1	2
R	207. mS	5.42 g's	18.01 g's	134.80 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 18 Gs; PEAK G (Z) = 15 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 6179, SAE ARP 1967.

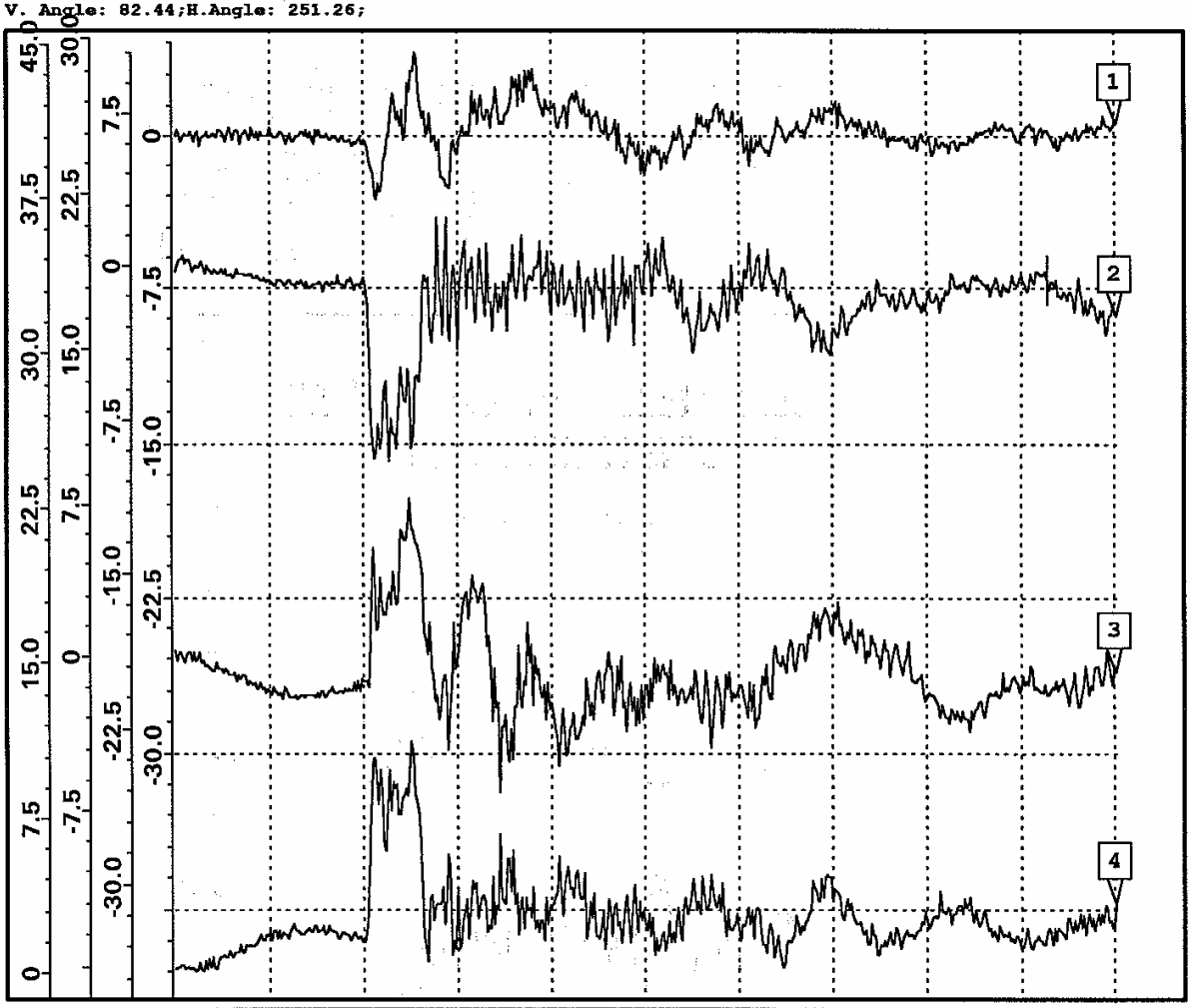
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

	Aug 26 2004 14:47	TEST ENGINEER :	Evans
TEST TYPE :	Edgewise Impact	IMPACT POINT :	Left-bottom edge
CONTAINER/ITEM:	C17 Post	DROP HEIGHT :	12 inches

V. Angle: 82.44;H.Angle: 251.26;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○	1	242. mS	0.27 g's	4.69 g's	23.51 In/s	26 mS	1	2
◉	2	242. mS	-0.64 g's	-9.76 g's	-140.06 In/s	26 mS	1	2
○	3	242. mS	-1.90 g's	8.10 g's	-82.07 In/s	26 mS	1	2
○	R	241. mS	1.99 g's	12.08 g's	164.03 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 12 Gs; PEAK G (Z) = 10 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 6179, SAE ARP 1967.

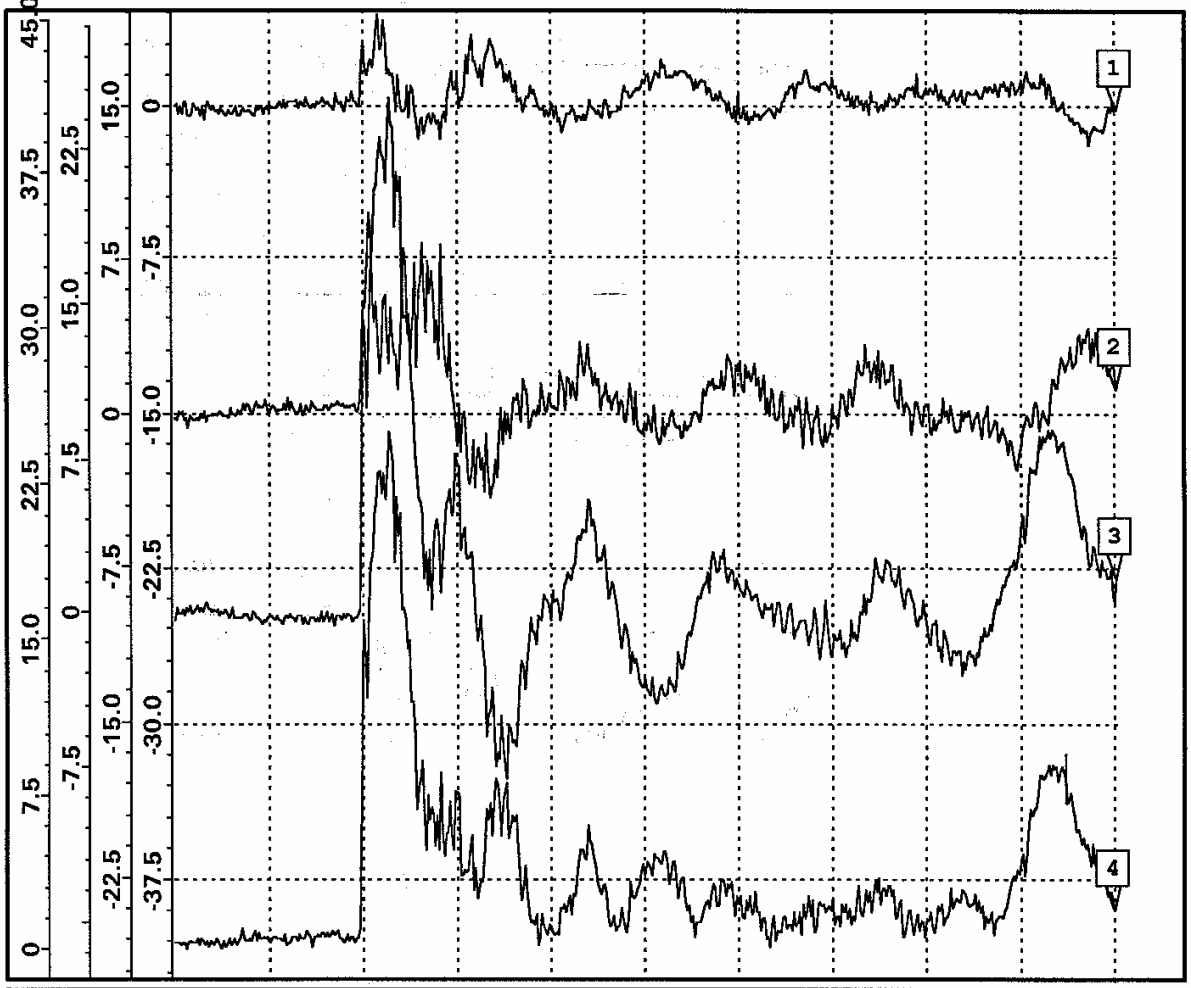
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

ROTATIONAL DROP TEST

Aug 26 2004 14:51 TEST ENGINEER : Evans
TEST TYPE : Edgewise Impact IMPACT POINT : Right-bottom edge
CONTAINER/ITEM: C17 Post DROP HEIGHT : 12 inches

V. Angle: 92.86;H.Angle: 74.73;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	247. mS	-0.39 g's	4.92 g's	49.96 In/s	26 mS	1	2
2	247. mS	2.08 g's	9.94 g's	63.19 In/s	26 mS	1	2
3	247. mS	7.62 g's	25.99 g's	128.23 In/s	26 mS	1	2
R	247. mS	8.29 g's	26.10 g's	151.43 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 26 Gs; PEAK G (Z) = 26 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 6179, SAE ARP 1967.

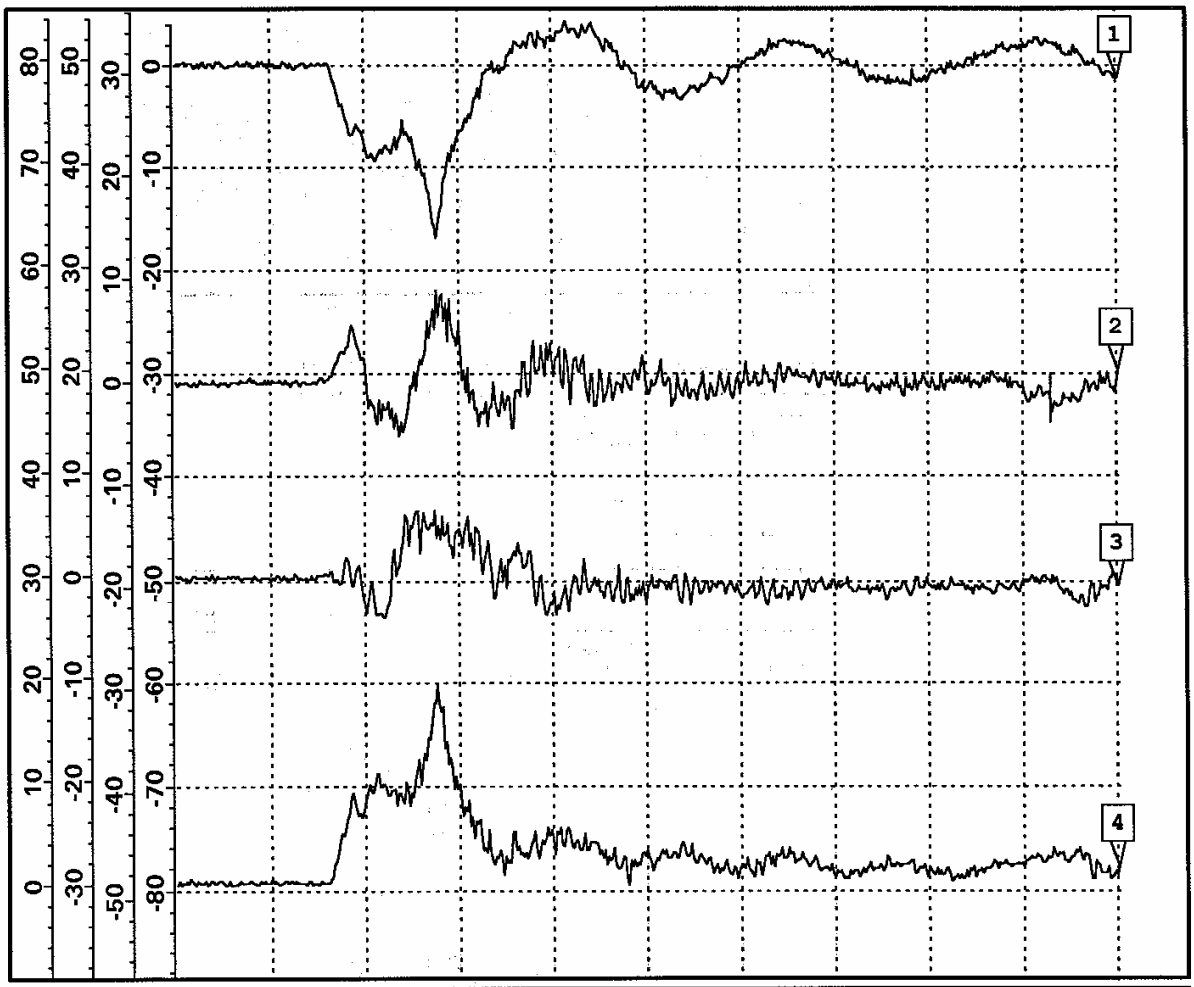
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

PENDULUM IMPACT TEST

	Aug 26 2004 9:58	TEST ENGINEER :	Evans
TEST TYPE :	Pendulum Impact	IMPACT POINT :	Forward side
CONTAINER/ITEM:	C17 Post	IMPACT VELOCTY:	2.19 m/s

V. Angle: 38.88;H.Angle: 205.32;



	Ch.	Time		Curr Amp	Peak Amp	1st Int	Time/Div		Hexp	Vexp
○	1	242.	mS	2.17 g's	-17.31 g's	-90.19 In/s	26	mS	1	2
◉	2	242.	mS	-1.58 g's	9.79 g's	14.66 In/s	26	mS	1	2
○	3	242.	mS	-0.75 g's	7.62 g's	-26.72 In/s	26	mS	1	2
○	R	242.	mS	2.79 g's	20.03 g's	95.20 In/s	26	mS	1	2

PEAK G RESULTANT VALUE = 20 Gs; PEAK G (X) = 17 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 880, SAE ARP 1967.

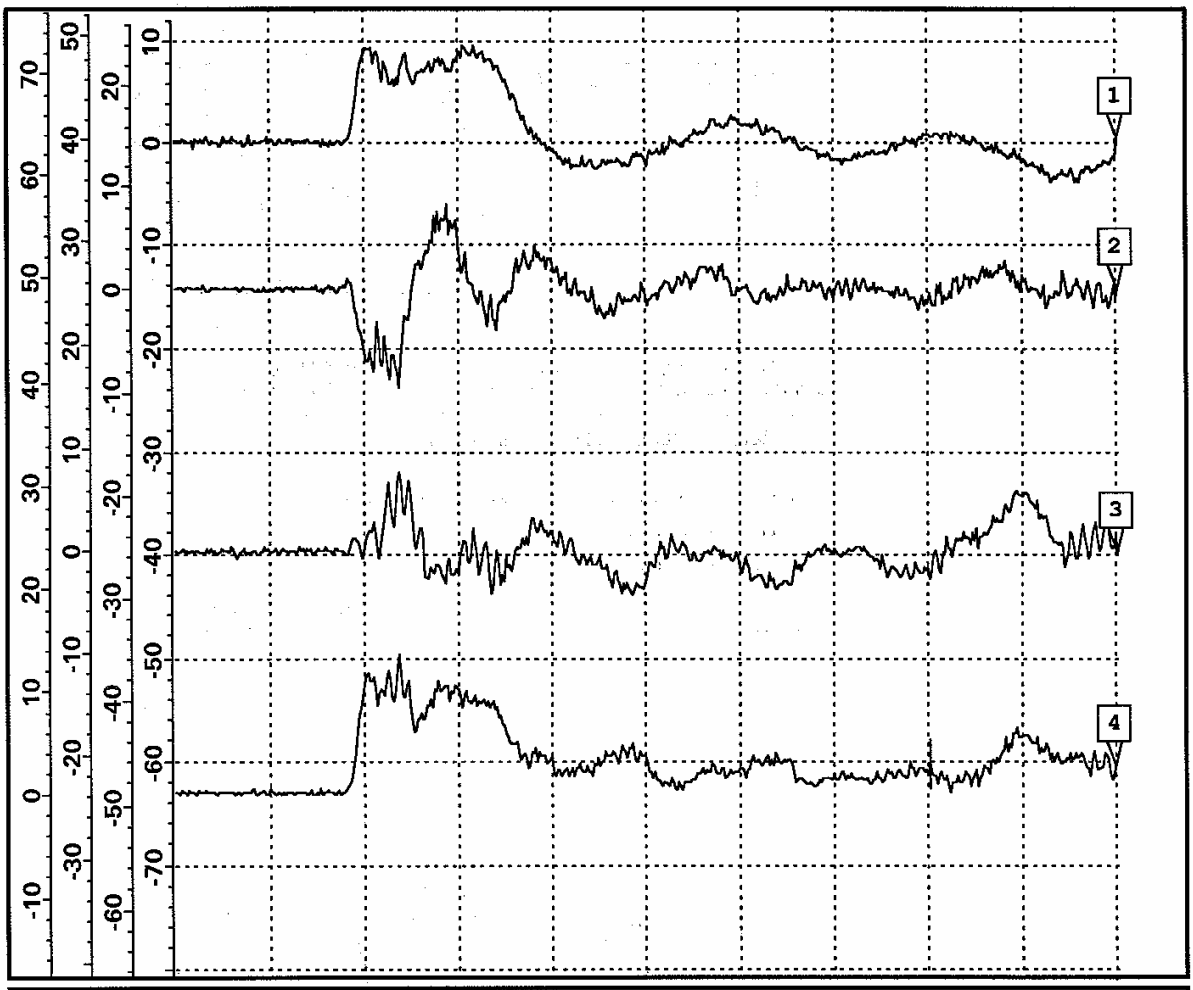
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

PENDULUM IMPACT TEST

	Aug 26 2004 10:42	TEST ENGINEER :	Evans
TEST TYPE :	Pendulum Impact	IMPACT POINT :	Aft side
CONTAINER/ITEM:	C17 Post	IMPACT VELCTY :	2.19 m/s

V. Angle: 73.79;H.Angle: 260.75;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
◯	1	209. mS	0.76 g's	9.94 g's	117.05 In/s	26 mS	1	2
◯	2	209. mS	-0.42 g's	-10.24 g's	-9.01 In/s	26 mS	1	2
◯	3	209. mS	-2.60 g's	8.24 g's	-28.05 In/s	26 mS	1	2
◉	R	209. mS	3.04 g's	14.69 g's	120.70 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 15 Gs; PEAK G (Y) = 10 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 880, SAE ARP 1967.

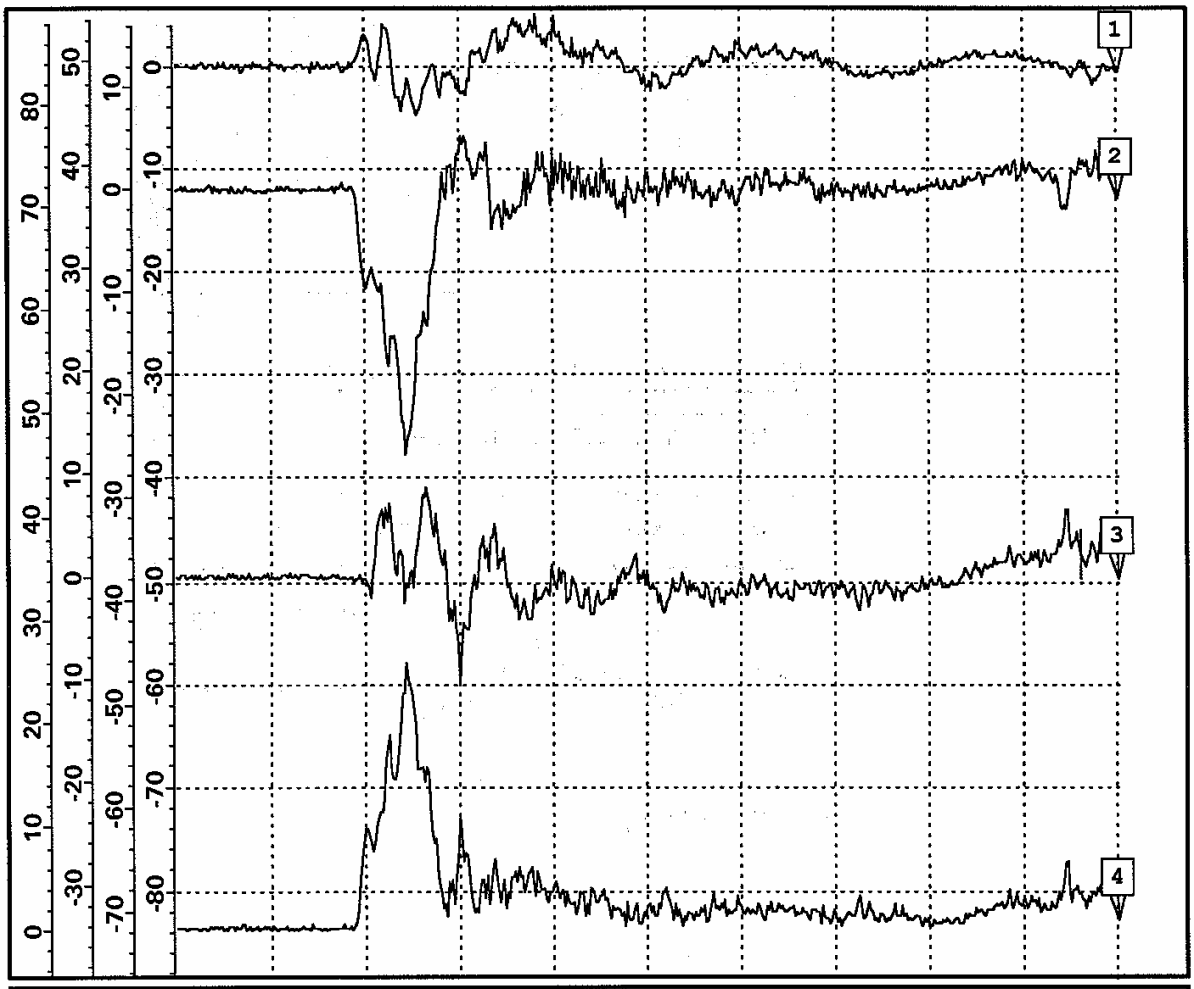
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

PENDULUM IMPACT TEST

	Aug 26 2004 10:34	TEST ENGINEER :	Evans
TEST TYPE :	Pendulum Impact	IMPACT POINT :	Left side
CONTAINER/ITEM:	C17 Post	IMPACT VELCTY :	2.19 m/s

V. Angle: 81.13;H.Angle: 37.48;



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	250. mS	0.56 g's	6.42 g's	39.10 In/s	26 mS	1	2
2	250. mS	2.84 g's	-26.09 g's	-84.61 In/s	26 mS	1	2
3	250. mS	2.18 g's	-11.03 g's	-13.64 In/s	26 mS	1	2
R	250. mS	3.62 g's	26.23 g's	94.20 In/s	26 mS	1	2

PEAK G RESULTANT VALUE = 26 Gs; PEAK G (Y) = 26 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 880, SAE ARP 1967.

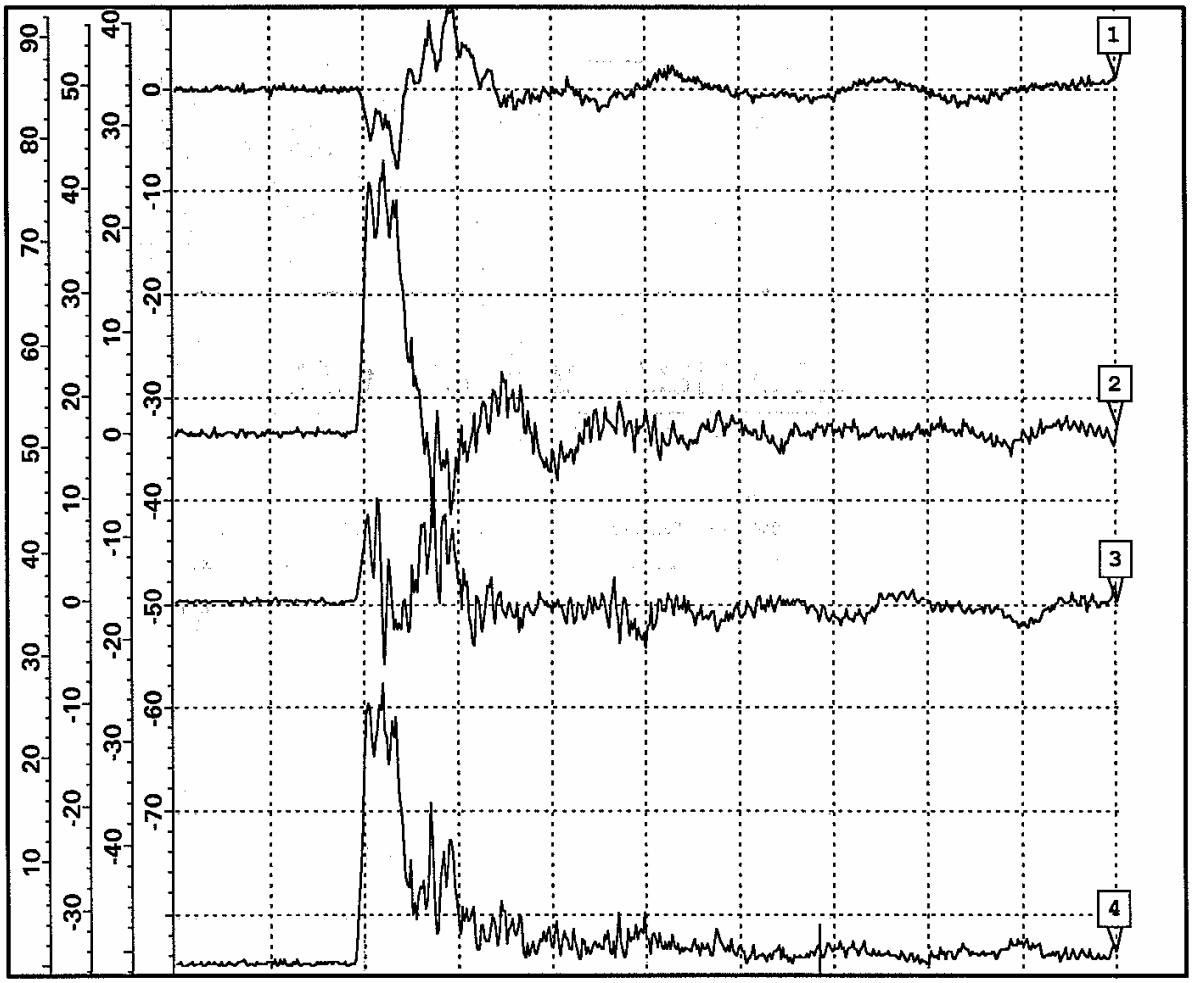
GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

PENDULUM IMPACT TEST

	Aug 26 2004 10:28	TEST ENGINEER :	Evans
TEST TYPE :	Pendulum Impact	IMPACT POINT :	Right side
CONTAINER/ITEM:	C17 Post	IMPACT VELCTY :	2.19 m/s

V. Angle: 110.81;H.Angle: 286.64;



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○	1	178. mS	-0.75 g's	8.67 g's	8.81 In/s	26 mS	1	2
○	2	178. mS	0.56 g's	26.54 g's	105.76 In/s	26 mS	1	2
○	3	178. mS	-1.89 g's	12.25 g's	2.43 In/s	26 mS	1	2
◉	R	178. mS	1.67 g's	27.49 g's	106.15 In/s	26 mS	1	2

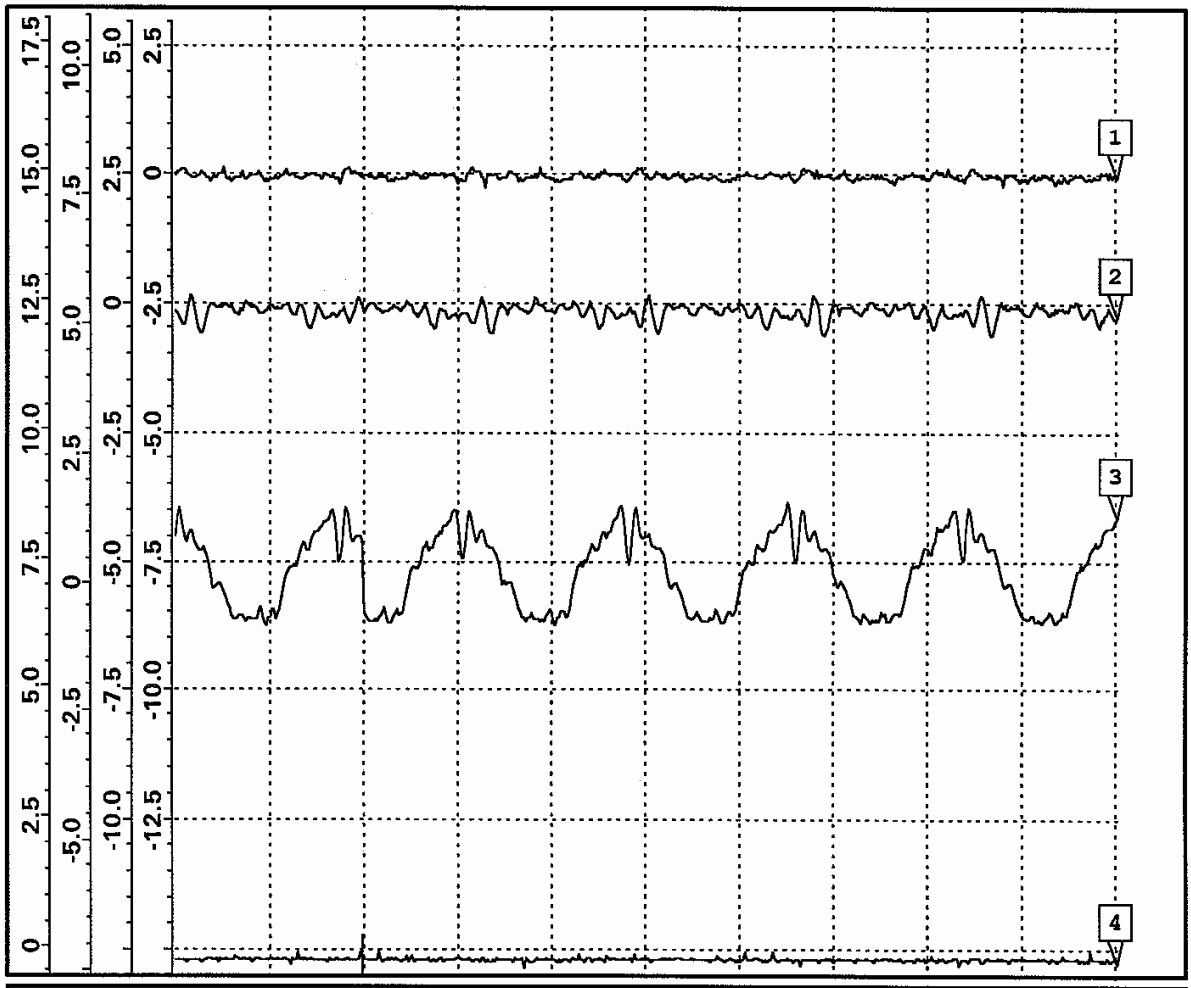
PEAK G RESULTANT VALUE = 27 Gs; PEAK G (X) = 27 Gs.
ACCELEROMETER OUTPUT: Ch1 - X(longitudinal); Ch2 - Y(transverse);
Ch3 - Z(vertical); Ch4 - resultant.
No visible damage.
ASTM D 4169, ASTM D 880, SAE ARP 1967.

GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

REPETITIVE SHOCK TEST

	Aug 20 2004 9:02	TEST ENGINEER :	Evans
TEST TYPE :	Repetitive shock	FREQUENCY :	4.3 Hz
CONTAINER/ITEM:	C17 Post	TIME IN TEST :	25 minutes



Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
1	179. mS	-0.09 g's	-0.34 g's	-4.58 In/s	131 mS	1	2
2	174. mS	-0.02 g's	-0.68 g's	-8.21 In/s	131 mS	1	2
3	171. mS	0.57 g's	1.60 g's	-0.68 In/s	131 mS	1	2
4	258. mS	-0.27 g's	-0.42 g's	-24.86 In/s	131 mS	1	2

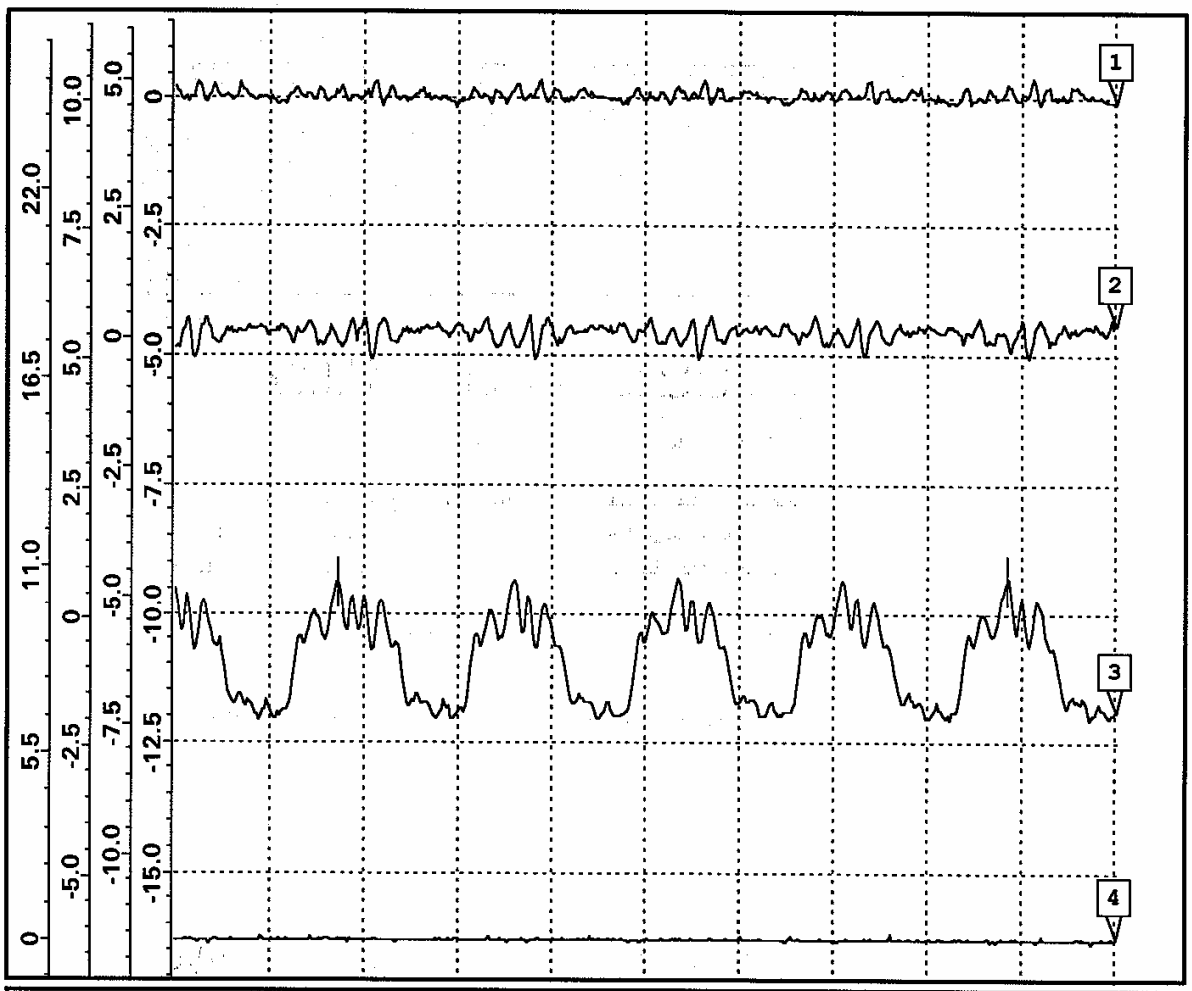
ACCELEROMETER OUTPUT: CH1 - X(long.); CH2 - Y(trans.); CH3 - Z(vert.);
CH4 - unused.
No visible damage.
ASTM D 4169, ASTM D 999; SAE ARP1967.

GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

REPETITIVE SHOCK TEST

Aug 27 2004 14:10 TEST ENGINEER : Evans
TEST TYPE : Repetitive shock FREQUENCY : 4.3 Hz
CONTAINER/ITEM: C17 Post TIME IN TEST : 1 hour



	Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○	1	345. mS	0.10 g's	0.47 g's	9.43 In/s	131 mS	1	2
○	2	330. mS	0.11 g's	0.58 g's	11.94 In/s	131 mS	1	2
◉	3	929. mS	0.76 g's	-2.08 g's	-336.96 In/s	131 mS	1	2
○	4	302. mS	0.01 g's	0.18 g's	1.62 In/s	131 mS	1	2

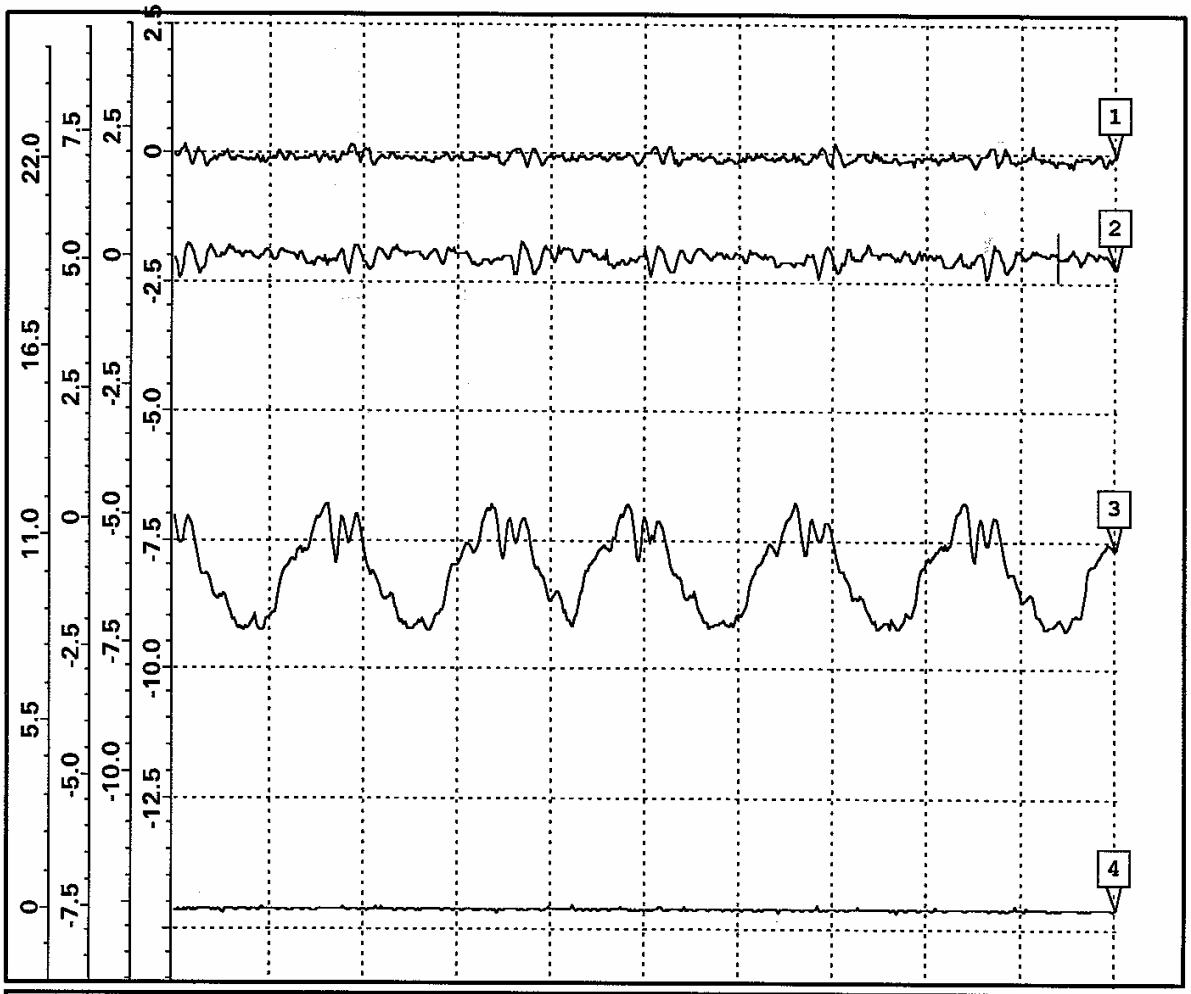
ACCELEROMETER OUTPUT: CH1 - X(long.); CH2 - Y(trans.); CH3 - Z(vert.); CH4 - unused.
No visible damage.
ASTM D 4169, ASTM D 999; SAE ARP1967.

GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY

REPETITIVE SHOCK TEST

Aug 30 2004 9:34 — TEST ENGINEER : Evans
TEST TYPE : Repetitive shock — FREQUENCY : 4.3 Hz
CONTAINER/ITEM: C17 Post — TIME IN TEST : 2 hours



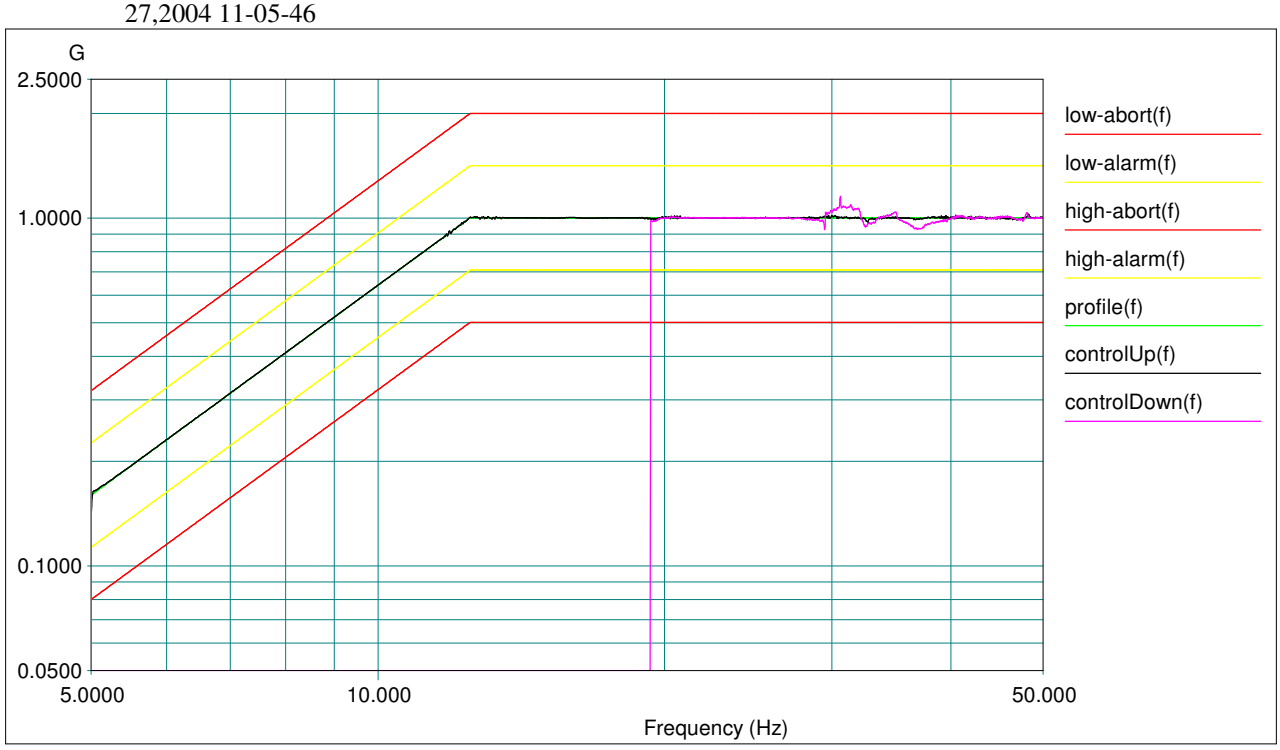
Ch.	Time	Curr Amp	Peak Amp	1st Int	Time/Div	Hexp	Vexp
○ 1	1.24 S	-0.16 g's	-0.40 g's	-35.68 In/s	131 mS	1	2
◉ 2	1.23 S	0.01 g's	-0.58 g's	-15.14 In/s	131 mS	1	2
○ 3	1.24 S	-2.12 g's	-2.33 g's	-493.55 In/s	131 mS	1	2
○ 4	320. mS	-0.02 g's	-0.17 g's	-0.63 In/s	131 mS	1	2

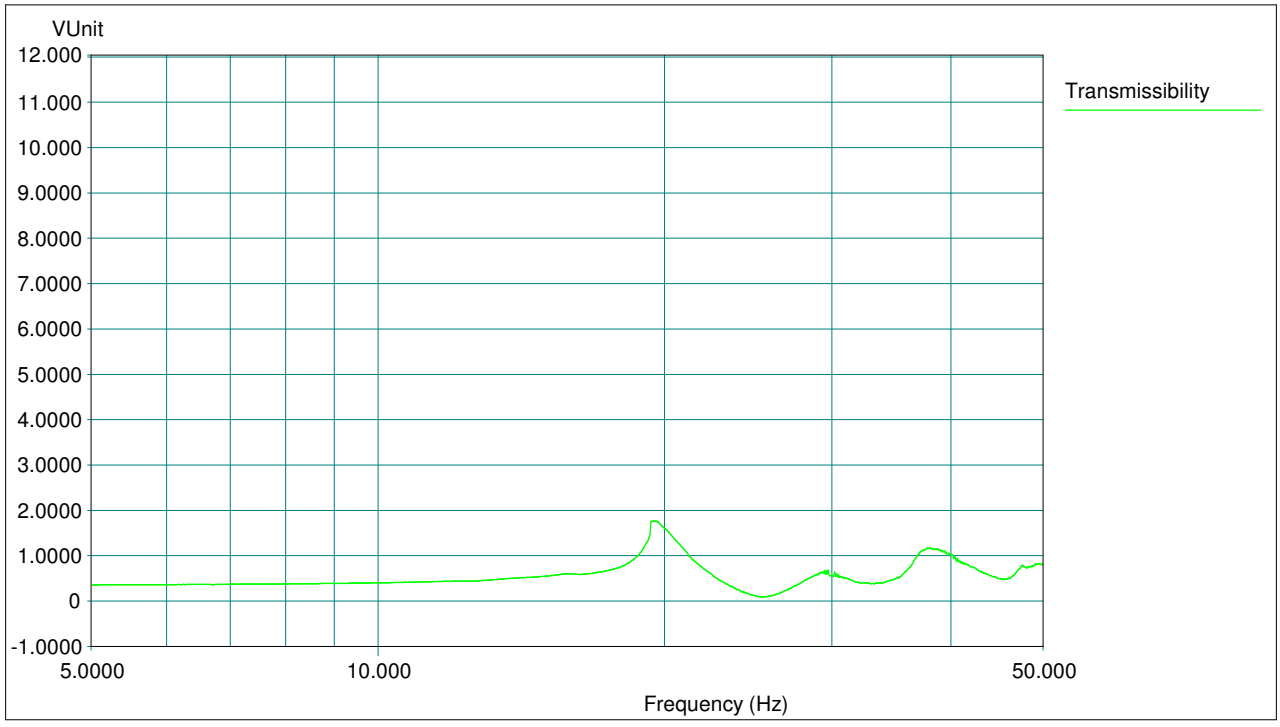
ACCELEROMETER OUTPUT: CH1 - X(long.); CH2 - Y(trans.); CH3 - Z(vert.); CH4 - unused.
No visible damage.
ASTM D 4169, ASTM D 999; SAE ARP1967.

GHI SYSTEMS, INC. CAT SYSTEM

C17 POST ASSEMBLY
SINE SWEEP

Test Engineer: Evans
Profile Name: 1.0G & 0.05In Pk-Pk. Test Type: Swept Sine Run Folder:. \Run Aug 27,2004 11-05-46





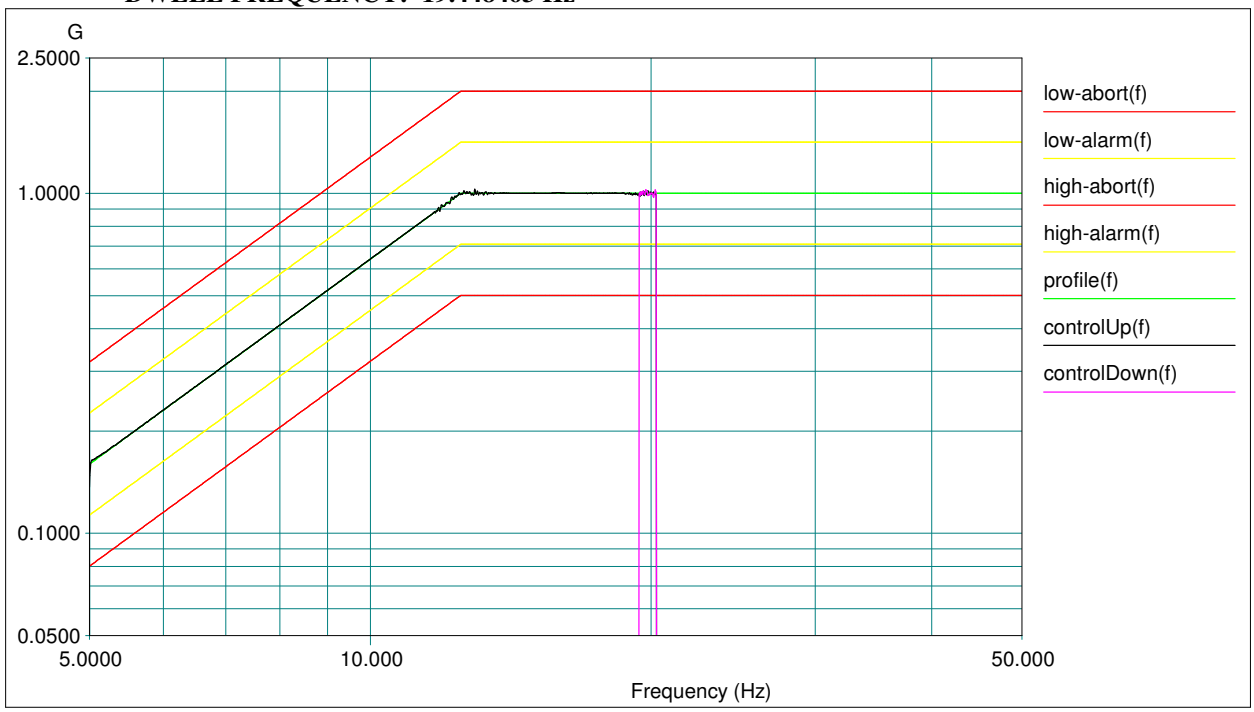
Level: 0 dB Control Peak: 0.978936 G Sweep Type: Logarithmic
Frequency: 19.357359 Hz Demand Peak: 1.000000 G Sweep Rate: 0.5 Oct/Min

C17 POST ASSEMBLY

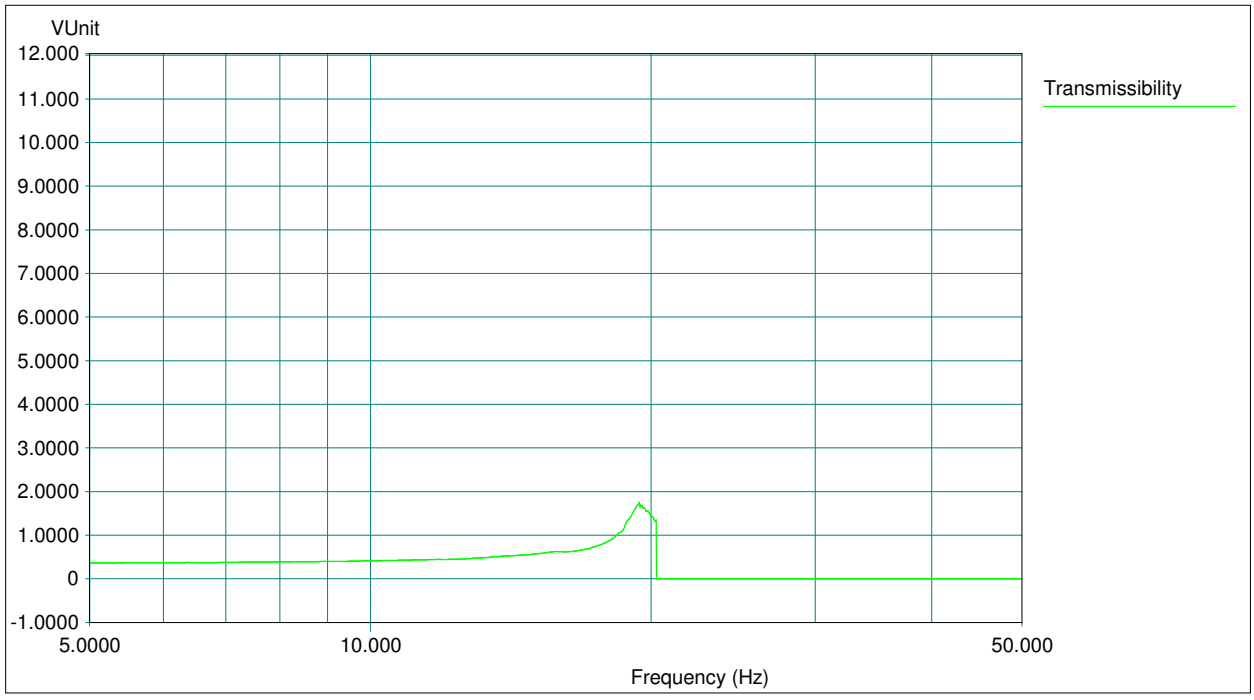
RESONANCE DWELL

TEST ENGINEER: Evans Dwell Time: 8 minutes
Profile Name: 1.0G & 0.05In Pk-Pk. Test Type: Sine Dwell Run: Aug 27,2004 11-30-23

DWELL FREQUENCY: 19.448463 Hz



TRANSMISSIBILITY: 1.8

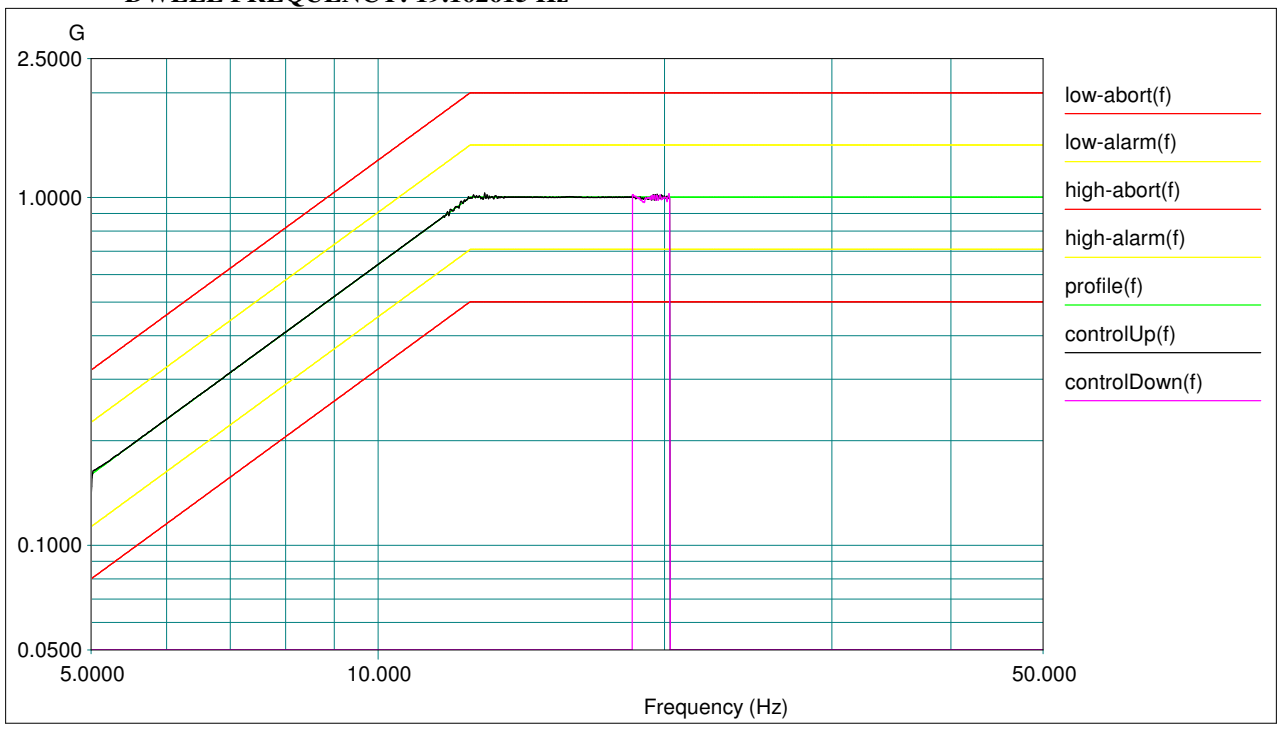


Level: 0 dB Control Peak: 1.004630 G Sweep Type: Logarithmic
Demand Peak: 1.000000 G Sweep Rate: 0.5 Oct/Min

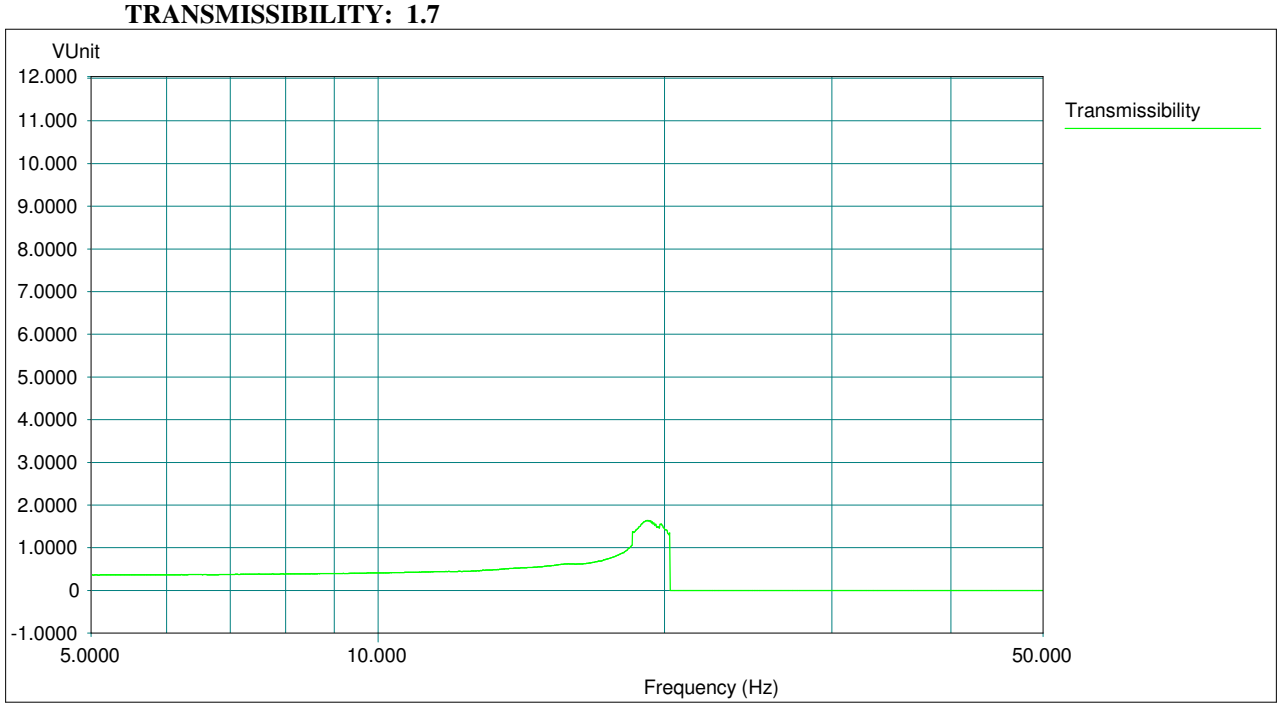
C17 POST ASSEMBLY
RESONANCE DWELL

TEST ENGINEER: Evans
Profile Name: 1.0G & 0.05In Pk-Pk.
Aug 27,2004 11-30-23
Dwell Time: 15 minutes
Test Type: Sine Dwell
Run:

DWELL FREQUENCY: 19.162615 Hz



TRANSMISSIBILITY: 1.7

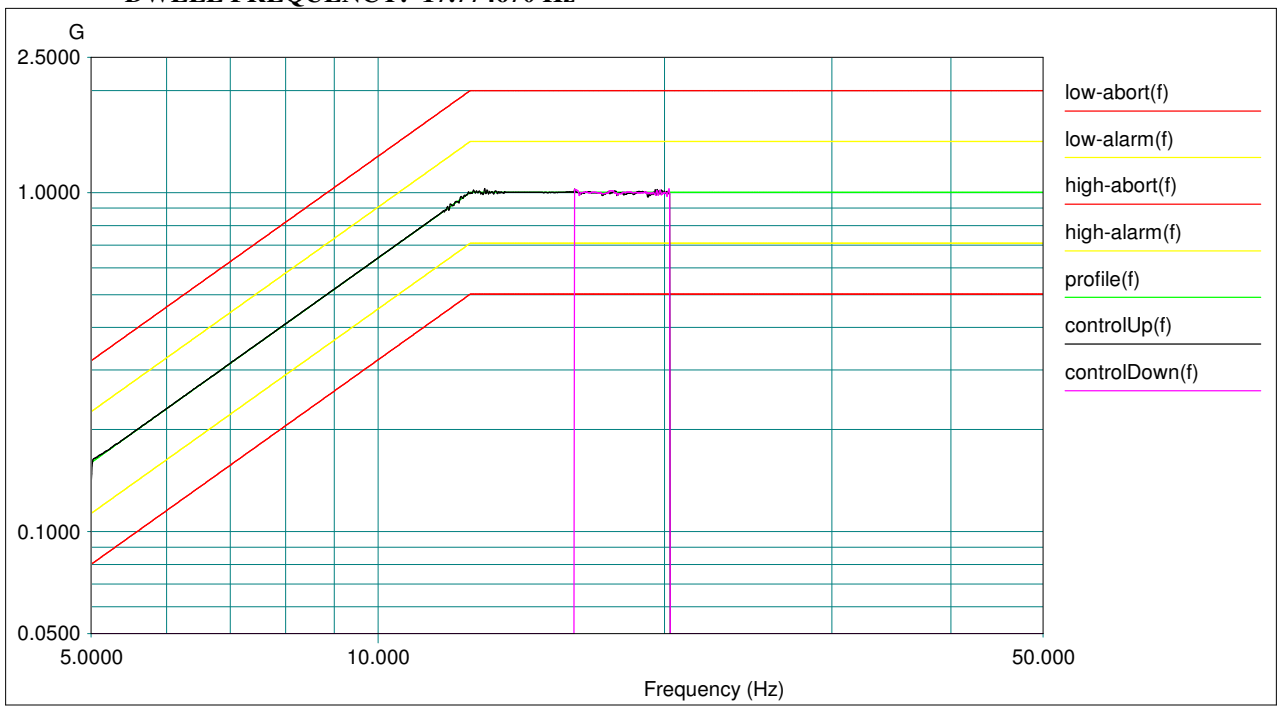


Level: 0 dB
Frequency: 19.162615 Hz
Control Peak: 0.999482 G
Demand Peak: 1.000000 G
Sweep Type: Logarithmic
Sweep Rate: 0.5 Oct/Min

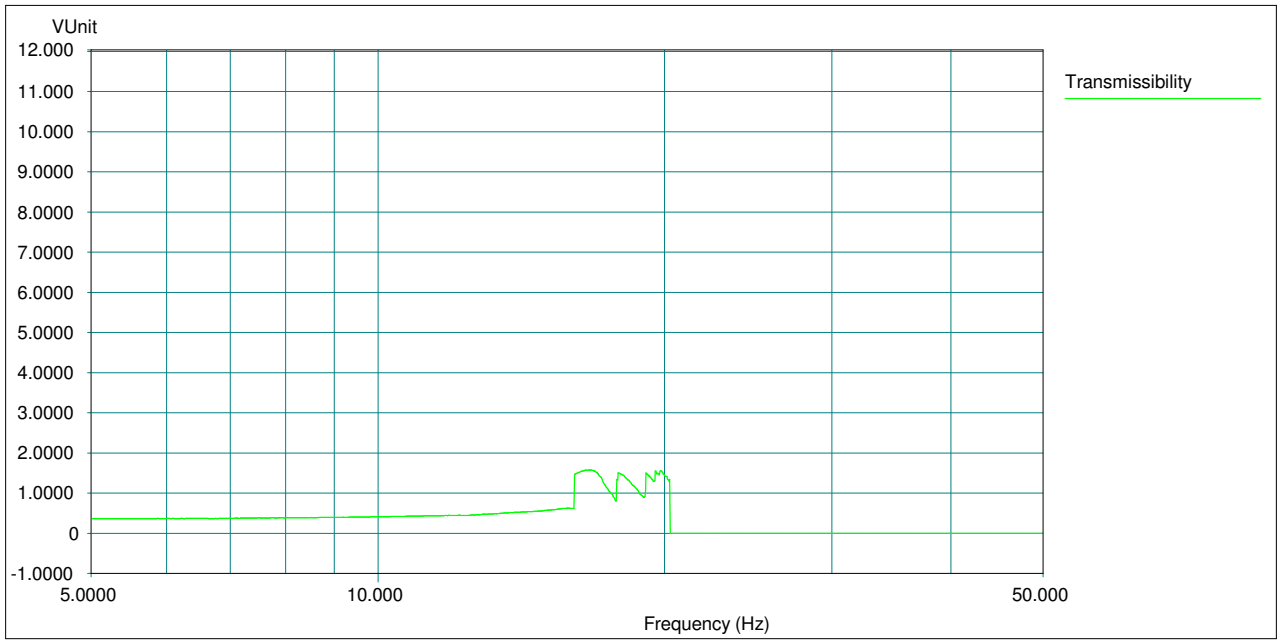
C17 POST ASSEMBLY
RESONANCE DWELL

TEST ENGINEER: Evans
Profile Name: 1.0G & 0.05In Pk-Pk.
Aug 27,2004 11-30-23
Dwell Time: 28 minutes
Test Type: Sine Dwell
Run:

DWELL FREQUENCY: 17.774670 Hz



TRANSMISSIBILITY: 1.6



Level: 0 dB
Frequency: 17.774670 Hz
Control Peak: 0.999482 G
Demand Peak: 1.000000 G
Sweep Type: Logarithmic
Sweep Rate: 0.5 Oct/Min

APPENDIX 4: Test Instrumentation

PRESSURE TEST EQUIPMENT - Test sequence 1 & 6.

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Digtal Manometer	Yokogawa	2655	82DJ6001	N/A

ROUGH HANDLING TEST EQUIPMENT - Test sequences 2 through 5.

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Shock Amplifier	Endevco	2740BT	GB04	Jun 04
Shock Amplifier	Endevco	2740BT	FW23	Jun 04
Shock Amplifier	Endevco	2740BT	FW26	Jun 04
Post Accelerometer	Endevco	2223D	FF67	Jun 03
Data Acquisition	GHI Systems	CAT	Ver. 2.7.1	N/A

VIBRATION TEST EQUIPMENT - Test sequence 2 & 3.

EQUIPMENT	MANUFACTURER	MODEL	SN	CAL. DATE
Servohydraulic Vibration Machine	Team Corp.	Special	1988	N/A
Feedback Hardware Controller	Dactron Corp.	PCI DSP Card Front End DSP Box	2208515 4544828	Aug 04 N/A
Feedback Software Controller	Dactron Corp.	Version 2.1	N/A	N/A
Table Feedback Accelerometer	Endevco	2271AM20	10306	N/A
Feedback Amplifier	Endevco	2775A	EL65	N/A

APPENDIX 5: Distribution List

DISTRIBUTION LIST

DTIC/O
DEFENSE TECHNICAL INFORMATION CENTER
FORT BELVOIR VA 22060-6218

AFMC LSO/LO
WRIGHT-PATTERSON AFB OH 45433-5540

448 MSUG/GBMST
TINKER AFB OK 73145

84 MSUG/GBMUM
HILL AFB UT 84056-5805

542 MSUG/GBMSCA
ROBINS AFB GA 31098-1670

564 ACSS/LTHS
ROBINS AFB GA 31098-1670

THE BOEING COMPANY
ATTN: GUY BREDESEN M/C C078-0432
2401 E WARDLOW RD
LONG BEACH, CA 90801-5608

APPENDIX 6: Report Documentation

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
21-08-2006	Technical, Final Project Report	May 04 - Sept 04

4. TITLE AND SUBTITLE

Development of the C-17 Main Landing Gear Post Container

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Matthew P. Bozzuto, Project Engineer
matthew.bozzuto@wpafb.af.mil, DSN 787-7166, Comm. (937) 257-7166

Susan J. Evans, Qualification test Engineer
susan.evans@wpafb.af.mil, DSN 787-7445, Comm. (937) 257-7445

5d. PROJECT NUMBER
04-P-103

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Packaging Technology and Engineering Facility
AFMC LSO/LOP
5215 THURLOW ST, STE 5, BLDG 70C
WRIGHT-PATTERSON AFB OH 45433-5540

8. PERFORMING ORGANIZATION REPORT NUMBER
06-R-03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Air Force Packaging Technology Engineering Facility (AFPTEF) was tasked with the design of a new shipping and storage container for the C-17 MLG Post in March of 2004. The new container is designed to replace the wood container that was previously used. The main problem with the wood design was corrosion due to inadequate environmental control and protection. In addition, there were two different container configurations to accommodate a left or right post. AFPTEF applied proven container design methods to solve the corrosion problem as well as simplified the container configuration to accept either right or left posts, eliminating the need for different containers. The CNU-677/E, designed to SAE ARP1967A, is an aluminum, long-life, controlled breathing, reusable shipping and storage container. The new container, CNU-677/E, protects the Post mechanically and environmentally. The container passed all qualification tests per ASTM D4169. The CNU-677/E container not only meets user requirements but also provides an economic saving for the Air Force. The savings will be thousands of dollars per MLG post over the twenty-year life span of the container.

15. SUBJECT TERMS
CNU-677/E, C-17 Main Landing Gear (MLG) Post Container, Aluminum Container, Reusable Container, Design, Test, Long-life

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Matthew P. Bozzuto
U	U	U	UU	42	19b. TELEPHONE NUMBER (Include area code) (937) 257-7166

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18